

SECTION 800. ELECTRICAL**GENERAL****SECTION 801. ELECTRICAL REQUIREMENTS - LIGHTING**

801.01 Definition. Codes, standards, and industry specifications cited for electrical work shall be by definition the latest adapted version thereof, unless indicated otherwise.

Materials and equipment by definition shall include fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, electrical installation.

801.02 Standards of Installation. Materials and equipment shall be installed according to the manufacturer's recommendations, the National Electrical Code, the National Electrical Safety Code and AASHTO's Standard Specifications For Structural Supports For Highway Signs, Luminaires and Traffic Signals.

801.03 Protection and Safety.

- (a) **Safety.** Electrical systems shall not be left in an exposed or otherwise hazardous condition. All electrical boxes, cabinets, pole handholes, etc. which contain wiring, either energized or nonenergized, shall be closed or shall have covers in place and be locked when possible, during nonworking hours.
- (b) **Protection.** Electrical raceway or duct openings shall be capped or otherwise sealed from the entrance of water and dirt. Wiring shall be protected from mechanical injury.

801.04 Marking Proposed Locations for Highway Lighting System. The Contractor shall mark or stake the proposed locations of all poles, cabinets, junction boxes, pull boxes, handholes, cable routes, pavement crossings, and other items pertinent to the work. A proposed location inspection by the Engineer shall be requested prior to any excavation, construction, or installation work after all proposed installation locations are marked. Any work installed without location approval is subject to corrective action at the Contractor's expense.

801.03 Inspection of Electrical Connections. Before any splice, tap, or ground connection is covered in handholes, junction boxes, light poles, or other enclosures, the Contractor shall notify and make available such wiring for the Engineer's inspection.

801.06 Damage to Electrical System. Should damage occur to any existing electrical systems through the Contractor's operations, the Engineer will designate the repairs as emergency or non-emergency in nature.

Emergency repairs will be made by the Department or its agent. Non-emergency repairs shall be performed by the Contractor within six working days following discovery or notification, to the satisfaction of the Engineer. All repairs shall be

performed in an expeditious manner to assure all electrical systems are operational as soon as possible. The cost of those repairs shall be the responsibility of the Contractor and no additional compensation will be allowed.

Temporary aerial multi-conductor cable, with grounded messenger cable, will be permitted if it does not interfere with traffic or other operations and if the Engineer determines it does not require unacceptable modification to existing equipment.

The outage will be considered an emergency when three or more lights on a circuit or three successive lights are not operational. Knocked down equipment which results in a danger to the motoring public will be considered an emergency repair.

801.07 Contract Guarantee. The Contractor shall provide a written guarantee for all electrical equipment, apparatus, materials, and workmanship provided under the contract for a period of six months after the date of final acceptance according to Article 801.13.

All instruction sheets required to be furnished by the manufacturer for materials and supplies and for operation of the equipment shall be delivered to the Engineer prior to acceptance of the project, with the following warranties and guarantees:

- (a) The manufacturer's standard written warranty for each piece of electrical equipment or apparatus furnished under the contract.
- (b) The Contractor's written guarantee that, for a period of six months after the date of final acceptance of the work, all necessary repairs to or replacement of said warranted equipment or apparatus shall be made by the Contractor at no cost to the Department.
- (c) The Contractor's written guarantee for satisfactory operation of all electrical systems furnished and constructed under the contract for a period of six months after final acceptance of the work.

801.08 Submittals. At the preconstruction meeting, the Contractor shall submit a written listing of manufacturers for all major electrical equipment items. The list of manufacturers shall be binding except by written request from the Contractor and approval by the Engineer. The request shall include acceptable reasons and documentation for the change.

Major equipment items shall be those items from the following list which are included in the project:

- Light Towers
- Light Poles
- Luminaires
- Lighting Controllers
- Unit Duct
- Cable

Within 30 days after contract execution, the Contractor shall submit, for approval, complete manufacturer's product data (for standard products and components) and detailed shop drawings (for fabricated equipment). Submittals for the equipment and materials for each individual pay item shall be complete in every respect. Submittals

which include multiple pay items shall have all submittal material for each item or group of items covered by a particular specification, grouped together and the applicable pay item identified. Various submittals shall, when taken together, form a complete coordinated package. A partial submittal will be returned without review unless prior written permission is obtained from the Department.

The Contractor shall have reviewed the submittal material and affixed his/her stamp of approval and signature. In case of Subcontractors submittal, both the Subcontractor and the Contractor shall review, sign, and stamp their approval on the submittal.

Receipt of the submittal information will be construed as the Contractor's assurance that the submittal has been reviewed and attests to the submittal's accuracy and conformance to the requirements of the contract. Any deviations to the contract shall be called out in the submittal. Illegible print, incompleteness, inaccuracy, or lack of coordination will be grounds for rejection. Equipment or material installed prior to approval by the Engineer, will be subject to removal and replacement at the Contractor's expense.

Exceptions, Deviations and Substitutions. In general, exceptions to and deviations from the requirements of the Contract Documents will not be allowed. It is the Contractor's responsibility to note any deviations from Contract requirements at the time of submittal and to make any requests for deviations in writing to the Engineer. In general, substitutions will not be acceptable. Requests for substitutions must demonstrate that the proposed substitution is superior to the material or equipment required by the Contract Documents. No exceptions, deviations or substitutions will be permitted without the approval of the Engineer.

Engineer's Stamp. After the Engineer reviews the submittals for conformance with the design concept of the project, the Engineer will stamp the drawings indicating their status as "Approved", "Approved As Noted", "Rejected", or "Information Only". Since the Engineer's review is for conformance with the design concept only, it is the Contractor's responsibility to coordinate the various items into a working system as specified. The Contractor shall not be relieved from responsibility for errors or omissions in the shop, working, or layout drawings by the Department's approval thereof. The Contractor must still be in full compliance with contract and specification requirements.

Resubmittals. All submitted items reviewed and marked "Approved As Noted", or "Rejected" are to be resubmitted in their entirety to verify contract compliance at no additional cost to the state unless otherwise indicated within the submittal comments.

801.09 Certifications. When certifications are specified and are available prior to equipment manufacture, the certification shall be included in the submittal information. When specified and only available after manufacture, the submittal shall include a statement of intent to furnish certification. All certifications shall be complete with all appropriate test dates, and data.

801.10 Record Drawings. Alterations and additions to the electrical installation made during the execution of the work shall be neatly and plainly marked in red on the full-size set of record drawings kept at the Engineer's field office for the project. These drawings shall be updated on a daily basis and shall be available for inspection by the Engineer during the course of the work. The record drawings shall

include all plans, details, notes, schedules, single line diagrams, etc., applicable to the electrical work and other information useful to locate and maintain the electrical system. As part of the record drawings, the Contractor shall inventory all equipment, new or existing, on the project and record information on inventory sheets provided by the Engineer. Upon request, a full-size set of reproducible drawings of the lighting work will be made available to the Contractor for the purpose of compliance with these requirements.

When the work is complete, and seven days before the request for a final inspection, the full-size set of contract drawings, stamped "RECORD DRAWINGS", shall be submitted to the Engineer for review and approval and shall be stamped with the date and the signature of the Contractor's supervising Engineer or electrician.

The Contractor shall provide two sets of professionally inked drawings in a moisture proof pouch to be kept on the inside door of the controller cabinet or other location approved by the Engineer. These drawings shall show the final as-built circuit orientation(s) of the project in the form of a single line diagram with all luminaires numbered and clearly identified for each circuit.

801.11 Testing

- (a) General. Before final inspection, the electrical equipment, material and work shall be tested. Tests may be made progressively as parts of the work are completed or may be made when the work is complete. Tests shall be made in the presence of the Engineer. Items which fail to test satisfactorily shall be repaired or replaced. Tests shall include checks of control operation, system voltages, cable insulation and ground resistance and continuity. The forms for recording test readings will be available from the Engineer. The equipment shall have the following minimum ranges and accuracies:

<u>Test</u>	<u>Type of Meter</u>	<u>Accuracy</u>
Voltage	Multimeter	+/-2% of reading
Insulation Resistance	Megohmmeter	+/-1% of reading
Current	Ammeter	+/-1% of reading
Ground Continuity	Low Ohm Meter	+/-1/4% of reading + 1 least significant digit

Meters shall be calibrated within the last year. Verification in the form of calibration certification documents shall be made available upon request of the Engineer.

- (b) Voltage Measurements. Voltages in the cabinet from phase to phase and phase to neutral at no load and at full load shall be measured and recorded. Voltage readings at the last termination of each circuit shall be measured and recorded.
- (c) Insulation Resistance. Insulation resistance to ground of each circuit at the cabinet, with all loads connected shall be measured and recorded.

On tests of new cable runs, the readings shall exceed 50 megohms for phase and neutral conductors with a connected load over 20 A and shall exceed 100 megohms for conductors with a connected load of 20 A or less.

On tests of cable runs which include cables which were existing in service prior to this contract, the resistance readings shall be the same or better than the readings recorded at the maintenance transfer at the beginning of the contract. Measurements shall be taken with a megohm meter approved by the Engineer.

- (d) Loads. The current of each circuit, phase main, and neutral shall be measured and recorded. The Engineer may direct reasonable circuit rearrangement. The current readings shall be within ten percent of the connected load based on equipment ratings.
- (e) Ground Continuity. Resistance of the system ground as taken from the farthest extension of each circuit run from the controller (i.e. check of equipment ground continuity for each circuit) shall be measured and recorded. Readings shall not exceed 2.0 Ohms regardless of the length of the circuit.
- (f) Resistance of Grounding Electrodes. Resistance to ground of all grounding electrodes shall be measured and recorded. Measurements shall be made with a ground tester during dry soil conditions as approved by the Engineer. Resistance to ground shall not exceed 10 Ohms.
- (g) Test Data. The Contractor shall provide the Engineer with a written report including the following:
 - (1) Date of test
 - (2) Number of days since last rain
 - (3) Soil condition at the time of the test
 - (4) Diagram of test set-up showing distances between test equipment and grounding electrode(s)
 - (5) Make, model and calibration date of test equipment
 - (6) Tabulation of measurements taken and calculations made

801.12 Maintain Lighting During Construction. Roadway lighting systems which are being replaced, including sign and navigation lighting, must remain operational throughout the project in accordance with Coast Guard requirements and as directed by the Engineer. No lighting circuit or portion thereof shall be removed from nighttime operation without the approval of the Engineer.

801.13 Final Inspection. When the work is complete, tested, and fully operational, the Contractor shall schedule a final inspection with the Engineer no less than seven working days prior to the desired inspection date. The Contractor shall furnish the necessary labor and equipment to make the final inspection.

A written record of the test readings taken by the Contractor according to Article 801.11 shall be furnished to the Engineer on or before the date the final inspection is scheduled. Final inspection will not be made until after the delivery of acceptable record drawings, specified certifications, and the required guarantees.

The final inspection and notice of acceptance shall be made according to Article 105.13

801.14 Equipment Grounding Conductor. All electrical systems, equipment and appurtenances shall be properly grounded in strict conformance with the NEC, even though every detail of the requirements is not specified or shown. Good ground continuity throughout the electrical system shall be assured. All electrical circuit runs shall have a continuous equipment grounding conductor. Where connections are made to painted surfaces, the paint shall be scraped to fully expose metal at the connection point and serrated connectors or washers shall be used. Where metallic conduit is utilized as the equipment grounding conductor, extreme care shall be exercised to assure continuity at joints and termination points. No wiring run shall be installed without a suitable equipment grounding conductor.

Bonding of all boxes and other metallic enclosures throughout the wiring system to the equipment grounding conductor shall be made using a splice and pigtail connection. All connections to structural steel or fencing shall be made with exothermic welds. Where connections are made to epoxy coated reinforcing steel, the epoxy coating shall be sufficiently removed to facilitate the exothermic weld. Where such connections are made to insulated conductors, the connection shall be wrapped with at least four layers of electrical tape extended 150 mm (6 in.) onto the conductor insulation.

SECTION 802. ELECTRICAL REQUIREMENTS - TRAFFIC SIGNALS

802.01 Inspection of Electrical Systems. Equipment. The Contractor shall prepare the traffic signal equipment at a suitable location, meeting the approval of the Engineer, so it may be readily inspected and tested by the Engineer. Prior to testing, all components shall be identified as to the vehicle movements. The inspector will tag the equipment that has been inspected and it may then be delivered to the job site. No equipment will be inspected unless a written request for inspection is delivered to the Engineer at least a week in advance. Equipment not complying with this requirement that has been installed on the job will be done at the Contractor's own risk and may be subject to removal and replacement at the Contractor's expense.

802.02 Damage to Electrical System. Any damage to the signal whether new or temporary from any cause shall be repaired or replaced by the Contractor at his/her own expense. The Contractor shall install "STOP" (R1-1-3636) signs on the approaches to the intersection as a temporary means of regulating traffic during the time of repair when required by the Engineer.

802.03 Contract Guarantee. The Contractor shall obtain warranties for all electronic and mechanical equipment which performs logic, timing, or communication functions from the manufacturers. These warranties shall be transferred to the Department or other maintaining agencies upon the completion and acceptance of the project. The warranties shall cover a minimum of six months from the date the equipment is placed in operation. The manufacturer shall warrant the equipment and all parts thereof against any defects of design, workmanship, and materials, and guarantee to promptly repair or replace, free of charge, any item that has become defective for reasons not proven to have been caused by negligence on the part of the user or acts of a third party during the warranty period.

802.04 Submittals. At the preconstruction meeting, the Contractor shall submit the following items for approval by the Engineer:

- (a) Five complete copies of the manufacturer's descriptive literatures and technical data for the traffic signal equipment that will be installed on the contract. The descriptive literatures and technical data shall be adequate for determining whether the equipment meets the requirements of the plans and specifications. If the literature contains more than one item, the Contractor shall indicate which item or items will be furnished.
- (b) Five complete copies of the shop drawings for the mast arm assemblies and poles and the combination mast arm assemblies and poles showing in detail the fabrication thereof and the certified mill analyses of the materials used in the fabrication, anchor rods, and reinforcing materials.
- (c) Samples of all conduit and cable, and samples of each type of cable splice that will be used in the work.
- (d) Unless otherwise approved by the Engineer, all of the above items shall be submitted to the Engineer at the same time. Each item shall be properly identified by route, section and contract numbers.
- (e) The Engineer will review the literature and furnish written approval or rejection to the Contractor within 15 calendar days after receipt of the literature. If the literature is rejected, the Contractor shall resubmit corrected literature within an additional 15 calendar days. Within ten calendar days after receipt of written approval of any signal material or equipment, the Contractor shall order such signal material or equipment and shall furnish a copy of such order to the Engineer.

802.05 Documentation for Electronic Equipment. The Contractor shall furnish the Engineer three copies of the following documentary items as furnished by the manufacturers and five copies of the controller cabinet wiring diagrams:

- Operation and service manuals.
- Electronic schematics of circuit boards.
- Pictorial layout of components of circuit boards.
- Parts list.

Documentary items shall be furnished for the following equipment:

- Signal controllers and master controllers.
- Inductive loop detectors and light detector amplifiers.
- Time base coordinators.
- Preemptors.
- Transceivers.
- Load switches.
- Conflict monitors.
- Any other equipment that performs a logic, timing or communication function.

802.06 Authorized Project Delay. On traffic signal contracts or contracts having traffic signal work as the controlling item, if requested and approved, the

Contractor may delay the start of work for a period of up to 120 consecutive calendar days after the execution of the contract for the delivery of signal material and equipment. This delay must be requested by the Contractor at or prior to the time of the preconstruction meeting.

The Contractor may request an additional delay over and above the 120-day period for nonstandard controllers and the associated equipment and/or nonstandard mast arm and poles. Nonstandard controllers and the associated equipment and/or nonstandard mast arms and poles will be interpreted as those differing significantly from these Specifications or the Highway Standards. A request for additional delay must be accompanied by written documentation from the manufacturer(s) of the nonstandard item(s), stating the anticipated delivery date to the Contractor. A copy of the Contractor's progress schedule showing the anticipated delivery date(s) will not permit completion of the project within the stipulated working days shall accompany the request.

The 120-day delay or such additional delay as may be approved will not be construed to require the Contractor to actually have the material on hand within such period, only that charging of working days will begin at the termination of the approved delay.

802.07 Maintenance and Responsibility. The Contractor shall be responsible for maintaining the traffic signal installation in proper operating condition.

The Contractor shall perform the following maintenance procedures:

- (a) Inspection. Patrol and inspect the signal installation at least once every two weeks for proper alignment of signal heads, lamp outages, and general operation of the traffic signals.
- (b) Correction. Provide immediate corrective action to replace burned-out lamps or damaged sockets with new approved lamps or sockets. At the time of replacement, the reflector and lens shall be cleaned.
- (c) Emergency Calls. Respond to emergency calls including but not limited to dark signals and unprogrammed flashing signals within two hours after notification and provide immediate corrective action. The Contractor shall maintain in stock a sufficient amount of material and equipment to provide temporary and permanent repairs. Any damage to the signal installation from any cause whatsoever shall be repaired or replaced by the Contractor at his own expense.

The Contractor shall install "STOP" (R1-1-3636) signs on all approaches to the intersection as a temporary means of regulating traffic during the time of repair when required by the Engineer.

- (d) Inspectors. The Contractor shall provide the Engineer the names and telephone numbers of two persons who will be available 24 hours a day, seven days a week, to perform any necessary work on the signal installation.
- (e) The Contractor's signal responsibilities of maintenance, energy charge, and damage repair shall begin and end as follows:

- (1) New Signal Installation. The signal responsibility shall begin at the start of signal construction and shall end upon issuance of Signal Acceptance Notice by the Engineer.
- (2) Modify Existing Signals. The signal responsibility shall begin at a date mutually agreed upon between the Contractor, Engineer, and the signal maintaining agency representative but no later than the beginning of construction by the Contractor within 125 m (400 ft) of the intersection. The signal responsibility shall end upon issuance of Signal Acceptance Notice by the Engineer.
- (3) Temporary Signals Used During Construction. The signal responsibility shall begin at the start of temporary signal construction and shall end with the removal of the signal as directed by the Engineer.

If, at any time, the Contractor fails to perform any work deemed necessary by the Engineer to keep the traffic signals in proper operating condition, or if the Engineer finds it impossible to contact the designated persons to perform any work, the Department reserves the right to have other electrical contractors perform the needed work. The cost of such work will be deducted from the amount due the Contractor.

802.08 Testing.

- (a) Detector Loop. Before and after permanently securing the loop in the pavement, electronic instruments shall be used to test the resistance, inductance, resistance to ground, and quality factor for each loop and lead-in circuit. The loop and lead-in circuit shall have an inductance between 50 and 700 microhenries. The resistance to ground shall be a minimum of 50 megohms under any conditions of weather or moisture. The quality factor (Q) shall be greater than 5. The Contractor shall provide the necessary instruments and do all the testing in the presence of the Engineer.
- (b) Fiber Optic Communication System.
 - (1) General. The Contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing.

The testing shall be performed in an accepted manner and according to the testing equipment manufacturer's recommendations. The test data shall be recorded and submitted to the Engineer.

- (2) Pre-installation Testing. An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and the length of each fiber on cable reels prior to their use on the project. The fiber loss in dB/km and the length of each strand shall be recorded in the documentation. The attenuation of each fiber shall not exceed 3.5 dB/km nominal, measured at room temperature at 850 nm, and the attenuation measured shall be compared against that recorded by the manufacturer.

A hard copy of OTDR signature traces for all fibers on each cable reel shall be printed and provided in the documentation to the Engineer.

- (3) Post-installation Testing. Each section of the cable shall be tested for the continuity and the attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an OTDR to locate points of localized loss caused by bends or kinks, and try to relax these bends or kinks. If this is not successful, the Contractor shall replace the damaged section of the cable with no additional payment. Splices shall not be allowed to repair the damaged section. The Contractor shall provide the Engineer with a written report showing all of the values measured during these tests.

- a. Attenuation Test. After installation, the end-to-end attenuation shall be measured for each link by insertion loss testing.

The launch reference cable and the receive reference cable shall provide for the attachments to the light source and to the power meter respectively. The fiber strand in the launch cable and in the receive cable shall be of the same size and type as the fiber under test.

The launch reference cable shall be connected to the light source and the receive reference cable to the power meter. The two reference cables shall then be connected via a patch panel. A reference power reading (P1) shall then be taken and recorded.

The system link to be tested shall then be inserted between the launch and the receive reference cables using two patch panels. A test power reading (P2) shall then be taken and recorded.

The link attenuation (A) in dB shall be recorded as the difference between the reference power (P1) and the test power (P2).

Link Attenuation, $A = P1 - P2$

Where P1 = Reference Power
P2 = Test Power

This test shall be performed in both directions along the link. The direction of the test shall be recorded in the documentation.

- b. Transmitter/Receiver Power Level Tests. The output levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation.

The power meter shall be connected to the transmitter side of the equipment with a system jumper. The transmit power level shall then be read and recorded. The transmitter is then reconnected to the cable link and the power meter connected to the receiver side of the equipment. The receiver power level shall then be read and recorded.

- c. Continuity Test. Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A

continuity test shall also be used to assure that the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receive fiber.

To perform continuity test, a high-intensity flashlight shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

- (4) Documentation. The results of all testing shall be recorded along with the date of the test; the name of the person performing the test; brand name, model number, serial number of the equipment used during the test; and any other pertinent information and data. The complete document set shall be submitted to the Engineer.

802.09 Acceptance. A signal, whether a new installation or an existing modified, will be accepted when the Contractor fulfills the traffic signal requirements of Section 800. Upon successful compliance with the requirements, the issuance of a written Signal Acceptance Notice by the Engineer will constitute the signal acceptance.

For interconnected signals the Signal System Acceptance Notice covering interconnection and system operation will be issued only after the compliance with the requirements on all signals, interconnection, and system operation. The Signal Acceptance Notice may be issued for individual signals under system control that meet all the non-system requirements.

802.10 Turn-on or Actuated Operation Inspection. The Contractor shall request a Turn-on Inspection of a new signal installation and an Actuated Operation Inspection of an existing modified signal after all the signal equipment has been completely installed and fully operable and when the roadway is open to traffic. For the interconnected signals (hardwire, fiber optic, or radio interconnect) all required system hardware and software including but not limited to internal and external modems, telephone drop, master controller, interconnect cable, and Closed Loop software shall be completely installed and fully operable prior to the system inspection request.

The inspection request must be made to the Engineer a minimum of three working days prior to the time of the requested inspection. During the inspection all the traffic control items will be tested for proper operation according to the contract and to the satisfaction of the Engineer. The Contractor shall be provided with a punch list indicating the items that failed the inspection and require corrective measures. Upon the Turn-on Inspection, the Engineer may allow the Contractor to activate the signal in continuous operation but this shall not relieve the contractor from correcting the failed items. The Contractor shall notify the Engineer when all the failed items on the punch list have been corrected and shall request an inspection. A Turn-on or Actuated Operation Inspection shall not be considered successful until each failed item on the punch list has been corrected by the Contractor to operate according to the contract and to the satisfaction of the Engineer. Only after a successful Turn-on or Actuated Operation Inspection shall the signals be considered ready for the Final inspection and a 30-day on-site acceptance period shall start.

802.11 Final Inspection (Thirty-day On-site Acceptance). After a successful Turn-on or Actuated Operation Inspection, the signals shall enter a 30

calendar days minimum on-site monitoring phase. During this phase the Contractor shall continuously monitor the operation of the traffic signal items including but not limited to controllers, master controller, inductive loop detectors, detector loop, transceivers, modems, conflict monitors and controller cabinets with peripheral equipment. If a Closed Loop system is being installed or being modified, the Contractor shall utilize the system software capabilities to monitor the traffic control items. Failure of any component during the monitoring period, with the exception of expendable items such as light bulbs and fuses, shall be reported to the Engineer and corrective measures shall be taken by the Contractor to the satisfaction of the Engineer. A failed item shall necessitate restarting the 30-day monitoring period for its full 30-day duration beginning at the time when the failed item was corrected by the Contractor to the satisfaction of the Engineer.

At the end of a successful 30-day monitoring period the Contractor shall provide the Engineer with a monitoring log for the items covering the 30-day period. The Contractor shall utilize the system software capabilities to store and generate monitoring logs, if a Closed Loop system is being installed or modified. Upon review of the logs and further equipment performance testing to the satisfaction of the Engineer, he/she will issue a Signal Acceptance Notice/Signal System Acceptance Notice or notify the Contractor in writing of the deficiencies.

SECTION 803. LOCATING UNDERGROUND CABLE

803.01 Description. This work shall consist of determining the exact locations of all underground electric cable and electric conductors in conduit owned and maintained by the Department which are in possible conflict with construction operations to protect them from damage.

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803.02 General. Any prints from microfilm or any information shown on the plans for existing underground electrical facilities owned and operated by the Department are intended to show electrical circuitry only, and are not intended to show exact locations of cable or conduits. The Contractor shall be responsible for determining the exact location of any such existing underground electric cable or electric conductors in conduit that are within 1.5 m (5 ft) of the limits of any excavation or penetration relative to the construction work that could interfere with the underground facilities.

Plans of existing Department owned electrical facilities may be available in the District Office in which the construction is located. Prints of applicable plans will be provided to the Contractor upon request, if available.

The Contractor shall take whatever precautions to protect the electric cable or electric conductors in conduit from damage during location and construction operations. In the event that the wiring is damaged, the Contractor shall replace the entire length of cable or conductors in conduit, in a manner satisfactory to the Engineer, at his/her own expense. Splicing below grade will not be permitted.

In the event the repairs are not made by the Contractor, the Contractor shall reimburse the Department for such repairs within 60 days of receiving written

notification of said damage. Otherwise, the cost of such repairs will be deducted from monies due or which will become due the Contractor under the terms of the contract.

If, in the opinion of the Engineer, it is determined prior to any construction that existing electrical wiring at a particular location is such that damage to said wiring is impossible to avoid, the Contractor shall relocate that segment of the existing wiring to avoid his/her operations as directed by the Engineer.

803.03 Method of Measurement. This work will be measured for payment in meters (feet) in place for each single buried insulated cable containing multiple conductors or for each single buried conduit containing multiple cables located within an area extending 1.5 m (5 ft) outside the limits of excavation or penetration in each direction. This work will be measured for payment at a specific work location only one time.

803.04 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for LOCATING UNDERGROUND CABLE, which price shall include locating each cable, or conduit and protecting it from damage during location and construction operations.

If the Contractor is requested to relocate a segment of cable or conduit at a specific work location to avoid construction operations, this work will be paid for in accordance with Article 109.04. Only that work requested in writing by the Engineer will be paid for.

SECTION 804. ELECTRIC SERVICE INSTALLATION - LIGHTING

804.01 Description. This work shall consist of all material and labor required to install, modify, or extend the electric service installation.

CONSTRUCTION REQUIREMENTS

804.02 Coordination. The Contractor shall contact and coordinate both the work required and the timing of the installation fully with the electric utility.

In the event of delay by the utility, no extension of time will be considered applicable for the delay unless the Contractor can produce evidence that a written request(s) for electric service has been sent to the utility. The initial written request must be dated no later than within 30 days from contract execution.

The total length of aerial and underground service between the controller and primary transformer shall not exceed 76 m (250 ft). The service pole or above ground pedestal and controller shall be located adjacent to the R.O.W. line or a minimum distance of 9 m (30 ft) from edge of pavement. Exact location shall be established by the Engineer.

804.03 Installation. The Contractor shall ascertain the work being provided by the electric utility and shall provide all additional material and work required to complete the electric service work in complete compliance with the requirements of the utility.

804.04 Materials. Materials shall be according to the following Article of Section 1000 – Materials.

Item	Article/Section
(a) Electric Service Installation-Lighting.....	1086.01

804.05 Basis of Payment. This work will be paid for at the contract unit price each for ELECTRIC SERVICE INSTALLATION which shall be payment in full for the work.

Any charges by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

No additional compensation will be allowed for work required for the electric service, even though not explicitly specified.

SECTION 805. ELECTRICAL SERVICE INSTALLATION - TRAFFIC SIGNALS

805.01 Description. This work shall consist of furnishing and installing an electrical service installation.

Type A service installation shall include one weather-head, one ground rod, one meter pan, one circuit breaker, one weatherproof enclosure, galvanized steel conduit, nonmetallic conduit, conduit clamps, lag screws, electric cables of the type and size specified by local utility company, and other miscellaneous items. The meter will be furnished by the utility company.

Type B service installation shall conform to the Type A service installation, except no meter will be installed.

Type C service installation shall include one weatherproof enclosure, one circuit breaker, one weather-head, one ground rod, galvanized steel conduit, conduit clamps, lag screws, electric cables of the type and size specified by a local utility company, and other miscellaneous items. The Contractor shall make connections to the line side of the circuit breaker, and coil the remainder above the junction box for installation by the utility company. No separate grounding of weatherproof enclosure will be installed, unless it is required by the utility company.

805.02 Materials. Materials shall meet the requirements of Article 1086.02.

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805.03 Installation. The service installation shall be installed according to the details shown on the plans. Exceptions will be made to comply with the local utility company's standard practices.

805.04 Basis of Payment. This work will be paid for at the contract unit price each for SERVICE INSTALLATION of the type specified, which price shall be payment in full for furnishing and installing the service installation complete. Any charges by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

SECTION 806. GROUNDING - LIGHTING

806.01 Description. This work shall consist of furnishing and installing a grounding electrode(s) and connecting the grounding electrode(s) by means of a grounding electrode conductor.

806.02 Materials. Materials shall be according to the following Article of Section 1000 – Materials.

	Item	Article/Section
(a)	Grounding Electrode Conductor.....	1087.01(a)
(b)	Grounding Electrode	1087.01(b)
(c)	Access Well	1087.01(c)

CONSTRUCTION REQUIREMENTS

806.03 Installation. Grounding electrodes shall be installed 150 mm (6 in.) above the bottom of the foundation hole in a cast-in-place concrete foundation or installed 450 mm (18 in.) below grade for other grounding applications. The grounding electrode conductor shall be attached to the grounding electrode by a mechanical ground clamp except in an access well where an exothermic weld connection shall be made. Access well installed grounding electrodes shall be buried 300 mm (12 in.) below grade and filled with crushed stone from the top of the grounding electrode to a point 500 mm (20 in.) below grade.

Testing resistance to ground shall be according to Article 801.11(f). If the measured resistance to ground exceeds 10 ohms, additional rods shall be added to the grounding electrode. A maximum number of three rods shall be coupled together. If coupling three rods together does not lower the resistance to 10 ohms, then additional grounding electrodes shall be installed, a minimum of 600 mm (24 in.) from the initial installation and connected by a grounding electrode conductor to form a ground field. If the resistance to ground still exceeds 10 ohms after three sets of three coupled electrodes, have been installed in the ground field or where sub-surface conditions limit the depth to which the grounding electrode(s) can be installed, the Contractor shall contact the Engineer for further instructions.

806.04 Method of Measurement. Each 3 m (10 ft) length of grounding electrode will be measured for payment.

806.05 Basis of Payment. This work will be paid for at the contract unit price per each for GROUNDING ELECTRODE IN FOUNDATION, GROUNDING ELECTRODE BELOW GRADE or GROUNDING ELECTRODE IN ACCESS WELL..

SECTION 807. GROUNDING – TRAFFIC SIGNALS

807.01 Description. The ground rod shall be a copper clad steel solid circular cross section with a nominal diameter of 19 mm (3/4 in.) and provide a minimum cumulative in-soil-contact length of 2.4 m (8 ft). Resistance to ground shall be

according to Article 801.11(f). The ground rod shall be installed so the acute angle between the rod and the vertical line is not greater than 45 degrees.

If a subsurface condition prohibits the installation of the ground rod to the required length, several ground rods providing a minimum cumulative in-soil-contact length of 2.4 m (8 ft) shall be bonded together into an array by a No. 6 AWG bare copper wire located 450 mm (18 in.) below finished grade, or the ground rod shall be buried in a trench at a minimum depth of 750 mm (2 1/2 ft).

A ground clamp capable of accommodating a No. 6 AWG bare copper wire shall be furnished with the rod.

POLE AND TOWER

SECTION 808. WOOD POLE

808.01 Description. This work shall consist of furnishing and installing a wood pole as shown on the plans, including all necessary hardware and accessories required for the intended temporary or permanent use of the pole.

808.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials.

Item	Article/Section
(a) Wood Pole Lighting	1069.01(d)
(b) Traffic Signal Wood Pole	1077.04

CONSTRUCTION REQUIREMENTS

808.03 Installation.

- (a) Highway Lighting. Previously used poles and appurtenant items will be acceptable under this item, upon physical inspection and approval by the Engineer.

Poles shall be in good condition as acceptable to the Engineer and shall be according to the applicable ANSI requirements for sweep, crook, defects and mechanical damage. Poles deemed unacceptable by the Engineer shall be removed from the jobsite.

Hardware shall also be made available for inspection by the Engineer and hardware deemed defective by the Engineer shall be removed from the job site and replaced with approved hardware. Hardware shall include cable hardware as well as pole hardware including insulators, cable supports, guy anchors, guy wires and the like.

As a minimum, pole guying shall be provided where indicated on the plans and at every dead-end pole and at any pole having non-offsetting cable support stresses.

Where mast arm equipment is indicated, the equipment shall be structurally sound and of the length and type specified. The Contractor shall obtain inspection and approval by the Engineer for any mast arm equipment. Where two luminaires are indicated as mounted on a common mast arm, a suitable duplex tenon adapter, complete with any required additional bracing shall be provided.

Poles shall be stored and handled according to ANSI 05.1.

Removal of all material and equipment furnished under this item shall not be included in this item unless it was determined by the Engineer to be defective.

- (b) **Traffic Signals.** The depth of the pole in the ground shall not be less than 20 percent of the pole length with a minimum of 1.8 m (6 ft). With span wire type installations, down guys or sidewalk guys shall be installed as shown on the plans, and the pole shall be raked 300 mm (1 ft). The backfill shall be tamped and compacted around the pole in 150 mm (6 in.) layers.

808.04 Basis of Payment. The work for highway lighting poles will be paid for at the contract unit price each for TEMPORARY WOOD POLE or WOOD POLE, of the length, class, and when specified, mast arm length and quantity indicated.

The work for traffic signal wood poles will be paid for at the contract unit price each for TRAFFIC SIGNAL WOOD POLE of the length and class specified.

SECTION 809. RESERVED

WIREWAY AND CONDUIT SYSTEM

SECTION 810. UNDERGROUND RACEWAYS

810.01 Description. This work shall consist of furnishing and installing raceways, fittings and accessories, either laid in trench, pushed in place, bored and pulled, or encased in concrete.

810.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Rigid Metal Conduit	1088.01(a)
(b) Rigid Nonmetallic Conduit	1088.01(b)
(c) Coilable Nonmetallic Conduit	1088.01(c)

CONSTRUCTION REQUIREMENTS

810.03 Installation. All underground conduit shall have a minimum depth of 750 mm (2 1/2 ft) or 600 mm (2 ft) below the finished grade as indicated on the plans.

(a) Rigid Metal Conduit (Steel, Intermediate Metal, Aluminum).

- (1) General. Installation shall be according to the applicable NEC Articles 345 and 346.

The ends of the conduit shall be cut square and thoroughly reamed before installation. All burrs and rough edges shall be removed.

Bends shall be made with a standard pipe bender. Bends shall be made so the conduit is not injured and the internal diameter of the conduit is not effectively reduced. The radius of the curve shall not be less than shown in Table 346-10 of the NEC or the larger radii specified.

Conduit joints shall be threaded. All joints before assembly and exposed threads after assembly shall be coated with low resistance, conductive, joint compound. Running threads in conduit runs will not be permitted. Conduits shall not be over-threaded. Threading shall be according to NEC Articles 345-8 and 346-7(b). The protective coatings on all threads must be sufficient to prevent corrosion before installation is made. If threads become corroded before installation, the material shall be replaced with new material or the corroded parts thoroughly cleaned and recoated as directed by the Engineer.

Ends of conduits shall be equipped with insulating bushings. Rigid metal conduits terminating in the base of lighting controllers, pedestal bases, transformer bases, and other open enclosures shall be equipped with insulating bushings with ground lugs. The ground lugs shall be used to bond the conduits to the enclosure via a copper grounding conductor.

Conduits terminating at cast or malleable iron boxes shall be terminated in conduit hubs. Hubs shall be integral to the box or installed separately. Non-integral hubs or integral hubs which do not provide a flared, smooth entry shall not be used where conductors are No. 4 or larger, and in these cases two locknuts and an insulating bushing shall be used.

Threaded conduits shall terminate with two locknuts and an insulating bushing for sheet metal enclosures above grade.

Conduit connections shall be made tight to assure good grounding continuity.

Conduit below pavement, used as sleeves, shall extend a minimum of 600 mm (2 ft) beyond the shoulder, curb, and/or guardrail.

The conduit shall be cleaned by rodding and swabbing to remove all dirt and other foreign materials and capped until conductors are installed.

- (2) Rigid Metal Conduit Pushed. Pushed conduit shall extend 600 mm (2 ft) beyond the edge of the paved shoulder surface. The Contractor shall be responsible for damage from work performed on any component of the roadway such as pavement, backslope, driveway, sidewalk, signs,

wiring, etc., and shall restore them to their original condition at his/her own expense as directed by the Engineer. Where rock or other obstructions such as broken concrete are encountered at push locations, alternate locations and/or methods may be approved by the Engineer for securing the conduit under the pavement as specified. Costs for moving push locations and restoration shall be considered included in the contract unit prices for the construction items involved and no additional compensation will be allowed.

Directional boring or augering may be considered as an alternate to pushed conduit.

(b) Rigid Nonmetallic Conduit.

- (1) General. Installation shall be according to NEC Article 347 Part A.

The conduit shall be cut square. All burrs shall be removed from the inside and outside of the conduit.

- (2) Bending. Bending of the conduit shall be made so the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced. Bends shall be made with standard pipe bending equipment for nonmetallic conduit.

The conduit section shall be heated evenly over the entire length of the bend. The use of torches or other flame-type devices will not be allowed. Sections showing evidence of scorching or discoloration will not be acceptable. The radius of the bend shall not be less than shown in Table 346-10 of the NEC.

- (3) Joints. All joints shall be test mated without forcing, then cemented. The socket depth of the fitting shall be marked on the outside of the conduit without scratching or damaging the surface. The conduit shall enter the fitting for the full depth of the socket.

Before applying cement, the surfaces to be joined shall be wiped clean and free of dirt, oil, grease, or moisture. The solvent cement shall be applied according to manufacturer's recommendations.

Immediately after applying the coat of cement to the conduit and fittings, the conduit shall be inserted into the fitting socket until it bottoms at the fitting shoulder. The conduit shall be turned 1/4 turn during insertion to distribute the cement evenly. Excess cement shall be wiped away from the outside of the joint.

Newly assembled joints shall set a minimum of ten minutes before handling.

- (4) Rigid Nonmetallic Conduit Pushed. Conduit shall be pushed according to Article 810.03(a)(2).

- (c) Coilable Nonmetallic Conduit. Coilable Nonmetallic Conduit shall be installed in continuous lengths, without splicing.

Conduit extended to lighting, traffic, and sign structures shall extend 300 mm (12 in.) above the base of the structure.

Bends of conduit shall be made manually so the duct will not be damaged and the internal diameter of the duct will not be effectively reduced. No more than the equivalent of four quarter bends (360 degrees total) shall be made between termination/pull points.

Coilable Duct, or Unit Duct, Bored and Pulled. A remotely steerable, fluid cutting tunneling system is to be used to install unit duct or empty continuous duct. The tunneling system shall be electronically detectable and shall line the tunnel with a clay lining as it tunnels. The tunneling system shall be approved by the Engineer prior to its use.

- (d) Concrete-encased conduit. Multiple conduit runs grouped together in a duct bank shall be encased in concrete and shall be supported on interlocking plastic spacers designed for the purpose, spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common duct bank shall be a minimum of 50 mm (2 in.). The interlocking spacers shall be used at a maximum interval of 15 m (5 ft).

Concrete cover overall shall be a minimum of 75 mm (3 in.) all around the encased run. During concrete placement there shall be no voids, the spacers shall be undisturbed, and the conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to or movement of the conduits.

Conduit encased in concrete shall have steel reinforcing when installed below roadway or other paved vehicle areas (including shoulder) and the reinforcement shall extend a minimum of 1.5 m (5 ft) additional from the edge of pavement. Steel reinforcement shall be a minimum of No. 15 (No. 4) bars at corners and otherwise spaced on 300 mm (12 in.) centers, tied with No. 15 (No. 4) bars on 300 mm (12 in.) centers.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

810.04 Method of Measurement. This work will be measured for payment in meters (feet) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction. Vertical conduit will be measured for payment. The vertical distance required for breakaway devices, barrier wall, concrete pedestals, etc., and the depth of any burial will be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps. Coilable nonmetallic conduit installed in excess of the limits described will not be measured for payment.

810.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CONDUIT IN TRENCH or CONDUIT PUSHED of the type and size specified, or POLYETHYLENE DUCT, BORED AND PULLED of the type and size specified, or CONDUIT ENCASED, of the type, diameter, and number of raceways wide by the number of raceways high specified.

SECTION 811. EXPOSED RACEWAYS

811.01 Description. This work shall consist of furnishing and installing raceways, fittings, and accessories attached to supports.

811.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Rigid Metal Conduit	1088.01(a)
(b) Expansion Fittings for Raceways	1088.02

CONSTRUCTION REQUIREMENTS

811.03 Installation.

- (a) Rigid Metal Conduit.
- (1) General. Rigid metal conduit installation shall be according to Article 810.03(a)(1). Conduits terminating in junction and pull boxes shall be terminated with hubs, integral box hubs or integral box bosses.
- (2) Supports. Surface-mounted conduits shall be held in place by one-hole clamps and clamp backs. Conduits mounted to steel beams or columns shall be held in place by suitable beam clamps. Clamps, clamp backs, and beam clamps shall be of hot-dipped galvanized steel or stainless steel.

Raceways suspended from the structure shall be supported by trapeze or other hangers approved by the Engineer. Trapeze hangers shall be hot-dip galvanized steel channels or angle irons with conduits held in place by heavy-duty stainless steel U-bolts, nuts, and lock washers. Trapeze hangers shall be hung using threaded hot-dipped galvanized or stainless steel rods not less than 12 mm (1/2 in.) diameter and appropriate anchors or by other means approved by the Engineer.

Raceway supports shall be installed according to NEC Article 346-12, with a support within 900 mm (3 ft) of each cabinet, box, or fitting except the maximum distance between supports shall be as indicated below. The listed exceptions in NEC Article 341-12 shall not apply.

Conduit Supports

Conduit Diameter		Maximum Distance Between Rigid Metal Conduit Supports	
mm	(Inches)	m	(ft)
13-20	(1/2-3/4)	1.5	(5)
25	(1)	1.8	(6)
30-40	(1 1/4-1 1/2)	2.1	(7)
50-65	(2-2 1/2)	2.4	(8)
75	(3) and larger	3	(10)

- (b) PVC Coated Rigid Steel Conduit. In addition to the methods described in Article 810.03(a) the following methods shall be observed when installing PVC coated conduit.

PVC coated conduit pipe vise jaw adapters shall be used when the conduit is being clamped to avoid damaging the PVC coating.

PVC coated conduit shall be cut with a roller cutter or by other means approved by the conduit manufacturer.

After any cutting or threading operations are completed, the bare steel shall be touched up with the conduit manufacturer's touch up compound.

- (c) Liquid Tight Metal Flexible Conduit. Flexible conduit shall not be used in lieu of bending conduit. Flexible conduit shall only be used to isolate structure to structure movement or to isolate vibration as shown on the plans.

Flexible conduit shall be installed according to NEC Article 351 and shall not exceed 900 mm (36 in.) in length unless approved by the Engineer. Fittings designed for use with liquid-tight flexible conduit shall be used at all connections.

- (d) Expansion Fittings. The fittings shall be precisely aligned with the conduit run to assure proper expansion and deflection operation and prevent binding.

For vertical conduit runs, the fitting shall be installed close to the top of the structure to prevent water running across the fitting and entering the conduit.

The fitting's deflection sleeve coupling, and pressure bushing at the barrel of the expansion body, shall be installed flush with the structure ends so that only the connecting expansion nipple crosses the opening between structures.

The fitting shall be supported by points on the conduit immediately adjacent to the fitting. The fitting shall have an external bonding jumper.

811.04 Method of Measurement. Conduit will be measured for payment in meters (feet) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction. Liquid-tight flexible

metal conduit will not be measured for payment, but shall be considered as included in the price for conduit attached to structure.

811.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CONDUIT ATTACHED TO STRUCTURE, of the type and diameter specified.

SECTION 812. RACEWAYS EMBEDDED IN STRUCTURE

812.01 Description. This work shall consist of furnishing and installing rigid conduit, fittings, and accessories embedded in concrete structures.

812.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Rigid Metal Conduit	1088.01 (a)
(b) Rigid Nonmetallic Conduit	1088.01 (b)
(c) Expansion Fittings for Raceways	1088.02

CONSTRUCTION REQUIREMENTS

812.03 Installation.

- (a) General. Conduit embedded in a structure shall be supported on interlocking plastic spacers specifically designed for that purpose and spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common structure shall be not less than 50 mm (2 in.). The interlocking spacers shall be used at a maximum interval of 1.5 m (5 ft). When approved by the Engineer, the conduit may be tied to the reinforcement where the reinforcement precludes the use of the supports.

Concrete cover shall not be less than 75 mm (3 in.) all around the embedded encased run. During concrete placement, spacers and conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to, or movement of, the conduits.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

Raceways shall be protected from mechanical and physical damage during construction. Open raceway ends shall be capped in accordance with manufacturer's recommendations. Raceways shall be cleared of all dirt, water, excess concrete, and other foreign materials with a dry swab and mandrel. Internal obstructions shall be repaired to the satisfaction of the Engineer.

The embedded conduit shall be continuous as shown on the plans, with no break or obstruction between junction boxes and through the entire raceway system. A 9 mm (3/8 in.) nylon rope shall be blown through following a

mandrel being pulled through the conduit to demonstrate continuity between junction boxes and through the entire raceway system. The size(s) of the mandrel shall be in accordance with the size(s) of the conduit as shown on the plans. The rope shall be left in the conduit, and shall be continuous between junction boxes and between all conduit terminal points. Each rope end shall be securely fitted with a washer or other approved device, of a diameter larger than the conduit diameter, to prevent the rope from coiling back inside the conduit and to insure accessibility for the installation of cables.

Continuity of the raceway system shall be demonstrated in the presence of the Engineer and all Contractors listed in the "Coordination With Adjacent and/or Overlapping Contracts" special provision. The Contractor shall notify the Engineer of raceway continuity testing prior to demonstration.

- (b) Rigid Metal Conduit. Conduit installation shall be according to Article 810.03(a)(1).
- (c) Rigid Nonmetallic Conduit. Conduit installation shall be according to Article 810.03(b).
- (d) Expansion Fittings. Expansion fittings shall be installed according to Article 811.03(d)

For rigid metal conduit the fitting shall have an external bonding jumper for the expansion part of the fitting and an internal bonding jumper for the deflection sleeve that spans the entire deflection sleeve fitting. No bonding jumper is required for rigid nonmetallic conduit.

812.04 Method of Measurement. Conduit will be measured for payment in meters (feet) in place. Measurements will be made in a straight line along the centerline of the conduit between ends and changes in direction. Vertical conduit will be measured for payment according to Article 810.04.

812.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CONDUIT EMBEDDED IN STRUCTURE, of the type and I diameter specified.

SECTION 813. JUNCTION AND PULL BOXES

813.01 Description. This work shall consist of furnishing and installing a junction or pull box.

813.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Stainless Steel Junction Box	1088.04
(b) Composite Concrete Junction Box	1088.05
(c) Cast Iron Junction Box	1088.07
(d) Concrete Junction Box	1088.06
(e) Reinforced Plastic Mortar Junction Box	1088.08
(f) Galvanized Steel Junction Box	1088.09
(g) Electrical Raceway Materials	1088.01

CONSTRUCTION REQUIREMENTS

813.03 Installation. Exposed junction boxes on structures shall be installed on 13 mm (1/2 in.) long stainless steel or brass spacers with the hinge on top of the box and the cover lying in the vertical plane when closed. The exact orientation shall be as shown on the plans or as directed by the Engineer. Care shall be taken to assure proper orientation of mounting lugs.

The embedded junction box shall be set flush with the adjoining surface and shall be properly supported during concrete placement. If located in shoulder area, the junction box shall be set in concrete with a minimum of 75 mm (3 in.) of concrete on each side and under the bottom of the junction box. Where a junction box is contiguous to sidewalk, preformed joint filler of 13 mm (1/2 in.) thickness shall be placed between the box and the sidewalk. Any backfilling necessary under a pavement, paved shoulder, sidewalk, or within 600 mm (2 ft) of the pavement edge shall be made with sand or stone screenings. The backfill shall be compacted according to Article 550.07.

Field cut conduit openings shall be uniform and smooth. All burrs and rough edges shall be filed smooth to the satisfaction of the Engineer prior to the installation of conduit(s) into the junction box. Field cut conduit openings shall be fitted with the appropriate conduit fittings and accessories. Conduit fittings and accessories shall be provided according to Article 1088.01 and as shown on the plans.

813.04 Basis of Payment. This work will be paid for at the contract unit price each for JUNCTION BOX; JUNCTION BOX, ATTACHED TO STRUCTURE or JUNCTION BOX, EMBEDDED IN STRUCTURE, of the type and size when specified. The Contractor may, with the approval of the Engineer, use box sizes larger than indicated, at no additional cost to the Department.

SECTION 814. HANDHOLE

814.01 Description. This work shall consist of furnishing the materials and constructing a handhole, a heavy-duty handhole, or a double handhole.

814.02 Materials. Materials shall meet the requirements of the following Article of Section 1000 - Materials:

Item	Article/Section
(a) Handholes	1088.10

CONSTRUCTION REQUIREMENTS

814.03 General.

- (a) **Placing Casting.** Castings shall be set accurately to the finished elevation so no subsequent adjustment will be necessary. Castings shall be set flush with sidewalk or paved surfaces. When installed in an earth shoulder away from

the pavement edge, the top surface of the casting shall be 25 mm (1 in.) above the finished grade.

- (b) Concrete. Concrete shall be cast in place, Class SI, and meet the requirements of Section 503. Where a handhole is contiguous to a sidewalk, preformed joint filler of 13 mm (1/2 in.) thickness shall be placed between the handhole and the sidewalk.
- (c) Backfilling. Any backfilling necessary under a pavement, paved shoulder, sidewalk, or within 600 mm (2 ft) of the pavement edge shall be made with sand or stone screenings. The backfill shall be compacted according to Article 550.07.
- (d) Cleaning. The handhole shall be thoroughly cleaned of any accumulation of silt, debris, or foreign matter of any kind.

814.04 Basis of Payment. This work will be measured and paid for at the contract unit price each for HANDHOLE; HEAVY-DUTY HANDHOLE; or DOUBLE HANDHOLE of the size and of the material type when specified.

SECTION 815. TRENCH AND BACKFILL FOR ELECTRICAL WORK

815.01 Description. This work shall consist of constructing and backfilling a trench for the accommodation of cables and raceways.

815.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Underground Cable Marking Tape	1066.05
(b) Backfill Material	1003.04

CONSTRUCTION REQUIREMENTS

815.03 General.

- (a) Trench. Trenches shall have a minimum depth of 600 mm (2 ft) or as otherwise indicated on the plans, and shall not exceed 300 mm (12 in.) in width without prior approval of the Engineer. The trenches shall be constructed to permit easy installation of cable or unit duct without twisting kinks, or sharp bends. Where conduit enters the trench, the bottom of the trench shall be built up with suitable compacted backfill material so the emerging unit duct or cable will have a smooth bed.

If the trench depth is less than 300 mm (12 in.) because of rock or concrete, the Contractor shall cut a groove in the obstructing material so the trench is 300 mm (12 in.) deep. The unit duct shall be laid in this groove and covered to grade with Class SI Concrete.

Where the trench depth exceeds 300 mm (12 in.), but less than 600 mm (2 ft), because of rock, the bottom shall be made smooth and free of short radius dips by filling low sections with trench backfill.

Where separate circuit runs are to be installed parallel with each other, one common trench shall be used. At the locations where a trench crosses other existing cable systems, the trench shall be hand dug 2 m (6.5 ft) to either side of the crossing.

The Contractor shall be responsible for damage incurred in any area of the project such as medians, pavement, shoulders, backslopes, driveways, and sidewalks and shall restore them to their original condition as directed by the Engineer.

- (b) **Plowed Installation.** Except where trenching is specifically indicated on the contract drawings, the Contractor shall have the option to plow unit duct or coillable nonmetallic conduit into place in lieu of trench and backfill.

Where coil raceway or cable is plowed-in, it shall be done by lay-in plow-feeding of the unit duct. Pulling of the polyethylene duct will not be allowed.

The coil, raceway, or cable shall be round and free of kinks when fed into the plow. Before final wire and cable connections are made, the Contractor shall demonstrate to the satisfaction of the Engineer, that all conductors within the duct are free to move.

Plowing, which places all duct, cable and conductors of a circuit in a single cavity so they are not twisted, kinked, or damaged and are the specified distance below grade, will be accepted as trench and backfill. Where another circuit is plowed in parallel to the first, the distance between the two shall be not less than 300 mm (12 in.) nor more than 600 mm (2 ft).

- (c) **Backfill.** Backfill shall be deposited in uniform layers not exceeding 150 mm (6 in.) thick loose measure. The material in each layer shall be mechanically compacted by tamping with power tools approved by the Engineer in such a manner as not to disturb, kink, or crush the cables, conductor, duct or conduit.
- (d) **Cable Marking Tape.** Underground cable marking tape shall be installed a minimum of 150 mm (6 in.) and not more than 300 mm (12 in.) below finished grade for all underground cable and raceway runs.

Underground cable marking tape with a reinforced metallic detection strip shall be used when specified. Splicing of the underground cable marking tape shall be accomplished with metal clips to maintain electrical continuity along the entire length of the tape. In addition to metal clips, all splices must be wrapped with a waterproof adhesive tape to prevent corrosion of the metal core.

815.04 Method of Measurement.

- (a) **Contract Quantities.** The requirements for the use of contract quantities shall be according to Article 202.07 (a).

- (b) Measured Quantities. This work will be measured in meters (feet) along the centerline of the trench. Trench and backfill will not be measured for payment for conduit which is pushed. Where separate circuit runs are placed in a common trench, only one run will be measured for payment along the centerline of the parallel portion.

815.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for TRENCH AND BACKFILL FOR ELECTRICAL WORK.

Excavation in rock will be classified and paid for as specified in Section 502.

WIRE AND CABLE

SECTION 816. UNIT DUCT

816.01 Description. This work shall consist of furnishing and installing preassembled cable in coilaible nonmetallic conduit (unit duct), complete with all splicing, identifications, and terminations.

816.02 Materials. Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Unit Duct	1066.01
(b) Coilaible Nonmetal Conduit	1088.01 (c)
(c) Conductors	1066.02
(d) Cable Insulation.....	1066.03

CONSTRUCTION REQUIREMENTS

816.03 Installation.

- (a) General. The unit duct shall be installed according to the NEC, directly from the reels on which the unit duct was shipped, in continuous spans without splices of any kind.

Where unit duct passes through handholes or pull boxes, the polyethylene duct shall be cut open and the continuous, uncut and unspliced conductors exposed and looped within the handhole or pull box. The ends of the polyethylene duct must be sealed with duct sealant and mounted in the handhole to prevent entrance of moisture or contaminants.

When the unit duct is to be pulled, the pulling apparatus shall be attached to the duct and not to the cables. The pulling tension on the duct shall not exceed 2.4 kN (550 lb).

Unit duct extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 450 mm (18 in.) out of pole

handholes. The duct of the unit duct assembly shall extend a minimum of 300 mm (12 in.) into pole shafts or transformer bases.

Minimum bending radius for the installed unit duct assembly shall be no smaller than the manufacturer's recommended radius. Bends shall be made so that the duct will not be damaged or kinked and the internal diameter of the duct will not be effectively reduced. There shall not be more than the equivalent of four quarter bends between pull points and no bend greater than 90 degrees.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

Splices and terminations shall be according to Article 1066.06.

- (b) In Trench. The unit duct shall be placed in the bottom of the trench after all loose or protruding stones have been removed or covered with backfill material as directed by the Engineer. The installation, after inspection by the Engineer, shall be backfilled according to Section 815.

The unit duct shall be installed at a minimum depth of 600 mm (2 ft) unless otherwise directed by the Engineer.

Where plowed, the unit duct shall be laid in place and the duct shall not be pulled through the length of the cut behind a bullet-nose mandrel or similar apparatus. Plowing operations shall be non-injurious to the duct.

- (c) In Raceway. Lubricating compounds shall be used where necessary to assure smooth installation.
- (d) Bored and Pulled. A remotely steerable, fluid cutting tunneling system is to be used to install the unit duct assembly. The tunneling system shall be electronically detectable and shall line the tunnel with a clay lining as it tunnels. The tunneling system shall be approved by the Engineer prior to its use.

816.04 Method of Measurement. The unit duct will be measured for payment in meters (feet) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and boxes access points. All vertical unit duct and permissible unit duct slack will be measured for payment according to Article 870.04.

816.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) installed for UNIT DUCT, 600V of the type, size, number and type of conductors and size of duct indicated.

SECTION 817. CABLE IN RACEWAY

817.01 Description. This work shall consist of furnishing and installing electric cables in conduit, complete with all splicing, identifications, and terminations.

817.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Conductors	1066.02
(b) Cable Insulation	1066.03

CONSTRUCTION REQUIREMENTS

817.03 Installation. Cable shall be installed without damaging the insulation.

Cable lubricant shall be used when pulling cables into conduits. The lubricant shall be non-injurious to conduits, conductors, insulations, or jackets.

Where a number of cables are trained through a box, manhole, or handhole, the cables shall be grouped by circuit where applicable and bundled using appropriate cable ties and supported to minimize pressure or strain on cable insulation.

Wire and cable extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 450 mm (18 in.) out of pole handholes.

Wire and cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. The cable shall be installed in continuous spans between termination points

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

Splices and terminations, as required, shall be according to Article 1066.06.

817.04 Method of Measurement. The cable will be measured for payment in meters (feet) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and boxes access points.

817.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) installed for ELECTRIC CABLE IN CONDUIT, 600 V of the type, size, and number of conductors indicated.

SECTION 818. AERIAL CABLE FOR LIGHTING

818.01 Description. This work shall consist of furnishing, installing and connection of aerial cable complete with all splicing, identifications, and terminations.

818.02 Materials. Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Conductors	1066.02
(b) Aerial Cable Insulation	1066.03(a)(3)
(c) Aerial Cable Assembly	1066.04

CONSTRUCTION REQUIREMENTS

818.03 Installation.

- (a) General. The luminaire connections to the aerial cable shall be made with listed parallel tap insulation piercing connectors. The connector shall be rated for 600 V and be listed under UL Standard 486B.
- (b) Temporary Installation. Upon written request of the Contractor, the Engineer may permit temporary portions of the work to be wired with previously-installed (used) aerial cable of ampacity equivalent to the specified cable and of a type and condition approved by the Engineer. The cable shall be left in place for the duration of the need for temporary wiring.

In addition to the wiring of temporary equipment indicated, the Contractor shall furnish and install electric feeders and make necessary equipment modifications to connect the existing system(s) to the temporary system(s). Buck-Boost Transformer(s), when indicated on the plans, shall be of the voltage and KVA indicated (or otherwise as applicable for the circuit), dry type, suitable for outdoor installation.

818.04 Method of Measurement. The aerial cable will be measured in meters (feet) in place and will be taken as the length of the messenger wire. Measurement will be made in a straight line between changes in direction and to the centers of light standards and control cabinets. Sag of the aerial cable or vertical cable will not be measured for payment. When the Engineer requests the used temporary cable be replaced with new, the new cable will be measured for payment.

Used aerial cable will not be measured for payment.

The rewiring to facilitate relocation of the cable due to staging or other construction requirements will not be measured for payment.

818.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for AERIAL CABLE WITH MESSENGER WIRE, of the type, size, and number of conductors specified.

SECTION 819. RESERVED

SECTION 820. RESERVED

LUMINAIRE

SECTION 821. ROADWAY LUMINAIRES

821.01 Description. This work shall consist of furnishing and installing a luminaire including branch circuit/extension, pole wire as applicable, lamp, fuseholders, mounting hardware, fusing, and surge protection.

821.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Luminaire	1067.01
(b) Wire in the Pole	1066.09
(c) Fuseholder & Fuses	1065.01
(d) Lamps	1067.02
(e) Fasteners and Hardware	1088.03
(f) Lightning Protection - Lighting	1065.02

CONSTRUCTION REQUIREMENTS

821.03 General Installation. Each luminaire shall be installed according to the luminaire manufacturer's recommendations.

Luminaires which are pole mounted shall be mounted on site such that poles and arms are not left unloaded. Pole mounted luminaires shall be leveled/adjusted after poles are set and vertically aligned before being energized. When mounted on a tenon, care shall be exercised to assure maximum insertion of the mounting tenon.

Each luminaire ballast and/or ballast arrangement shall be checked to assure compatibility with the project power system. When the luminaire has a multi-tap ballast, the tap shall be adjusted as necessary to assure a voltage match.

When the night-time check of the lighting system by the Engineer indicates that any luminaires are mis-aligned, the mis-aligned luminaires shall be corrected at no additional cost. Should the photometric results of the luminaire indicate, in the judgement of the Engineer, a tilt adjustment is warranted, the adjustment shall be made at no additional cost.

No luminaire shall be installed before it is approved. Where independent testing is required, full approval will not be given until complete test results, demonstrating compliance with the specifications, have been reviewed and accepted by the Engineer.

Pole wiring shall be provided with the luminaire according to Article 1066.09 at no additional cost. Included with the pole wiring shall be a surge arrester and fusing located in the handhole. Wire shall be trained within the pole or sign structure so as to avoid abrasion or damage to the insulation. The weight of the wire shall be properly supported within the pole or structure per NEC.

Pole wire shall be extended through the pole, pole grommet, luminaire ring and any associated arm and tenon. The pole wire shall be terminated in a manner that avoids sharp kinks, pinching, pressure on the insulation, or any other arrangement prone to damaging insulation value and producing poor megger test results. Wires shall be trained away from heat sources within the luminaire. Wires shall be terminated so all strands are extended to the full depth of the terminal lug with the insulation removed far enough so it abuts against the shoulder of the lug, but is not compressed as the lug is tightened.

When installing the lamp or performing any other activity that requires opening of the optical assembly, care shall be exercised to avoid touching the reflector or allowing contaminants to enter the assembly. Each lamp and lens shall be free of all dirt, smudges, etc. Should the reflector or refractor require cleaning, a mild soap or non-abrasive detergent, containing no chlorinated or aromatic hydrocarbons, shall be used and then rinsed clean with cold water and wiped dry.

821.04 Conventional Pole Installation. When the pole is bridge mounted, a minimum size stainless steel 1/4-20NC set screw shall be provided to secure the luminaire to the mast arm tenon. A hole shall be drilled and tapped through the tenon and luminaire mounting bracket and then fitted with the screw.

Horizontal mount luminaires shall be installed in a level, horizontal plane, with adjustments as needed to insure the optics are set perpendicular to the traveled roadway.

821.05 Highmast Installation. Luminaires having asymmetrical photometric distributions shall be carefully oriented with respect to the roadway as indicated on the plans and as directed by the Engineer. The Contractor shall confirm all luminaire orientations with the Engineer prior to installation.

For horizontal mounts having rotating optical assemblies, after the orientation of each mast arm tenon is inspected and approved by the Engineer, the position shall be permanently marked in a manner acceptable to the Engineer. The luminaire shall then be leveled to the plane of the luminaire ring.

When the luminaire position and orientation has been confirmed and approved by the Engineer, the luminaire shall be anchored with a minimum size 1/4-20NC stainless steel set screw installed through tapped holes in the tenon and mounting bracket of the luminaire. Counterweights on un-used tenons shall be mounted in a similar manner.

Pre-installed wire on the tower ring shall have the ends of each wire capped at the tenon with butt type crimp-connectors for un-used tenons. The wires shall then be re-inserted into the tenon end and the tenon end shall be capped.

821.06 Underpass Installation. When attached directly to a structure, the underpass luminaire shall have 25 mm (1 in.) stainless steel spacers installed between the luminaire and the structure.

When specified, an aluminum underpass luminaire numbering decal bracket for each underpass luminaire shall be installed as shown on the plan. The bracket shall be large enough to accommodate the identification and shall be mounted on the pier

or retaining wall from which the luminaires are electrically fed as directed by the Engineer.

When suspended, the underpass luminaire shall be installed 25 mm (1 in.) above the lowest underpass beam and shall be mounted parallel to the plan of the roadway, taking into consideration the applicable grade and superelevation of the traveled lanes. Vibration dampening assemblies shall be used and sized to the weight and shape of the underpass luminaire. All mounting hardware, except the vibration dampeners, shall be stainless steel.

821.07 Sign Lighting Installation. Each luminaire shall be mounted on the sign walkway structure with stainless steel hardware and with at least three points of attachment. The mounted luminaire or mounting hardware shall not extend above the bottom of the sign or below the bottom of the walkway support.

The center-to-center spacing of the luminaires will be determined by the Engineer. The end sections shall not exceed one-half the spacing between luminaires.

The mounting shall provide the correct position of the luminaire as recommended by the manufacturer and shall be able to withstand 130 km/h (80 mph) winds with a 1.3 gust factor. The sign lighting installation shall include a service disconnect with lockable exterior handle mounted within reach from the walkway.

Disabling brightness shall be shielded from traffic approaching either the front or back of the sign.

The mounted luminaire or mounting hardware shall not extend above the bottom of the sign or below the bottom of the walkway support.

821.08 Temporary Installation. Previously used luminaires will be acceptable for temporary lighting installations, providing all requirements of Section 821 are met and upon inspection and approval by the Engineer.

821.09 Basis of Payment. This work will be paid for at the contract unit price each for LUMINAIRE, of the type and wattage indicated.

SECTION 822. NAVIGATION OBSTRUCTION WARNING LUMINAIRES

822.01 Description. This item shall consist of furnishing and installing a navigation obstruction warning fixture complete with all supports, hardware, wiring, and connections to the structure or pole, and appurtenant mounting accessories.

822.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Waterway Obstruction Warning Luminaire	1067.03(a)
(b) Aviation Obstruction Warning Luminaire	1067.03(b)
(c) Fuseholders and Fuses	1065.01
(d) Lamps	1067.03
(e) Transformer, General Purpose.....	1068.02

CONSTRUCTION REQUIREMENTS

822.03 Installation. Mounting of the luminaire shall be as recommended by the luminaire manufacturer in such a manner that they clear all obstacles when retrieved for maintenance and relamping.

822.04 Basis of Payment. This work will be paid for at the contract unit price each for WATERWAY OBSTRUCTION WARNING LUMINAIRE or AVIATION OBSTRUCTION WARNING LUMINAIRE of the type, wattage, and color indicated.

SECTION 823. RESERVED

SECTION 824. RESERVED

CONTROLLER

SECTION 825. LIGHTING CONTROLLER

825.01 Description. This work shall consist of furnishing and installing an electrical control cabinet with control device(s), distribution equipment, foundation, and wiring for control of roadway lighting.

825.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Lighting Controller.....	1068.01
(b) Grounding for Lighting	1087.01
(c) Transformer, General Purpose.....	1068.02
(d) Lightning Protection - Lighting	1065.02

CONSTRUCTION REQUIREMENTS

825.03 Installation.

- (a) General. The construction and installation shall be according to NEC Article 373 and the NESC. The lighting controller installation shall be according to the details, location, and orientation shown on the plans.

A concrete work pad shall be provided in front of the cabinet, except where the cabinet faces a sidewalk.

The Contractor shall confirm the orientation of the lighting controller, and its door side, with the Engineer, prior to installing the foundation.

All conduit entrances into the lighting controller shall be sealed with a pliable waterproof material.

- (b) **Controller Mounted on Concrete Foundation.** The lighting controller enclosure or pedestal shall be set plumb and level on the foundation. It shall be fastened to the anchor rods with hot-dipped galvanized or stainless steel nuts and washers. Foundation mounted lighting controllers shall be caulked at the base with silicone.

Where the controller has a metal bottom plate, the plate shall be sealed with a rodent and dust/moisture barrier.

- (c) **Controller Mounted on Pole.** The lighting controller enclosure shall be mounted to the pole as shown on the plans. Aluminum brackets designed for pole mounting shall be used. Enclosures greater than 650 mm (26 in.) in height shall have stiffener plates on both top and bottom of the rear wall for mounting brackets. All mounting hardware shall be stainless steel.

- (d) **Controller Mounted on Wall.** The lighting controller enclosure shall be mounted to the wall with stainless steel fasteners as indicated in the plans. Stainless steel mounting brackets designed for wall mounting shall be used.

825.04 Ground Rod Access Well. When required, the cover of the ground rod access well shall be installed flush with the adjacent level grade at the location indicated on the plans. Crushed stone or gravel shall be packed and filled to a point approximately 100 mm (4 in.) below the exothermic connection. Excavated material shall be removed from the site.

825.05 Basis of Payment. This work will be paid for at the contract unit price each for LIGHTING CONTROLLER, of the enclosure and control type indicated.

SECTION 826. NAVIGATION OBSTRUCTION LIGHTING CONTROLLER

826.01 Description. This work shall consist of furnishing and installing an electrical control cabinet with control device(s), distribution equipment, foundation and wiring for control of navigation obstruction lighting.

826.02 Materials. Materials shall be according to the following Article of Section 1000 - Materials:

Item	Article/Section
(a) Navigation Obstruction Lighting Controller	1068.03

CONSTRUCTION REQUIREMENTS

826.03 Installation.

- (a) **General.** The construction and installation shall be according to the NEC.

The lighting controller installation shall be according to the details, location, and orientation shown on the plans.

The Contractor shall confirm the orientation of the lighting controller with the Engineer prior to installing the foundation.

All conduit entrances into the lighting controller shall be sealed with a pliable waterproof material.

- (b) **Controller Mounted on Concrete Foundation.** The lighting controller enclosure or pedestal shall be set plumb and level on the foundation. It shall be fastened to the anchor rods with nuts and washers which shall be hot-dipped galvanized or stainless steel. Foundation mounted lighting controllers shall be caulked at the base with silicone.

Where the controller has a metal bottom plate, the plate shall be sealed as a rodent and dust/moisture barrier.

- (c) **Controller Mounted on Pole.** Aluminum brackets designed for pole mounting shall be used. Enclosures greater than 650 mm (26 in.) in height shall have stiffener plates on both top and bottom of the rear wall for mounting brackets. All mounting hardware shall be stainless steel.

826.04 Basis of Payment. This work will be paid for at the contract unit price each for NAVIGATION OBSTRUCTION LIGHTING CONTROLLER, of the enclosure and control type indicated.

SECTION 827. Transformer, General Purpose

827.01 Description. This work shall consist of furnishing a dry type transformer, wiring, conduit and mounting hardware and installing it at the location shown on the plans or as designated by the Engineer.

827.02 Materials shall be according to the following Articles of Section 1000:-
Materials:

Item	Article/Section
(a) Transformer, General Purpose	1068.02
(b) Conduit	1088.01
(c) Wire and Cable	1066.02,03
(d) Splicing and Termination of Electric Cable	1066.06
(e) Fasteners and Hardware	1088.03

CONSTRUCTION REQUIREMENTS

827.03 Installation: General purpose transformers may be mounted inside a control cabinet, on a sign truss, and on a bridge structure requiring different mounting hardware. All material required to complete the installation shall be included. The transformer enclosure shall be NEMA 3R or 4X and may be stainless steel as shown on the plans. It shall be solid dielectric, air cooled, and of a type (i.e., buck/boost) as specified. The plans shall identify size in KVA as well as primary and secondary voltages. Air movement must be considered for mounting inside a junction box or other confined space. The completed installation shall fully comply with the NEC.

827.04 Basis of Payment: This work will be paid for at the contract unit price per each for TRANSFORMER, GENERAL PURPOSE, for the size, type, and location shown on the plans .

SECTION 828. RESERVED

SECTION 829. RESERVED

POLE AND TOWER

SECTION 830. METAL POLES

830.01 Description. This work shall consist of furnishing and installing a light pole complete with an arm(s), when specified, and all required hardware and accessories, including bolt covers, required for the intended temporary or permanent use of the pole.

830.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Light Pole	1069.01
(b) Mounting Pad	1069.03
(c) Pole/Unit Identification	1069.02

CONSTRUCTION REQUIREMENTS

830.03 Installation.

- (a) General. The light pole shall be set plumb on the foundation without the use of leveling nuts, shims or washers. On bridge parapet walls, a vibration mounting pad shall be installed between the foundation leveling plate and the light pole. The pole shall be set with proper orientation of the access handhole. On bridge parapet walls, the access handhole shall be oriented facing the roadway. Poles shall not be left in place without arm(s) and luminaire(s). The arm(s) shall be set at right angles to the centerline of the pavement.

Poles shall be without defect. Poles deemed unacceptable by the Engineer shall be removed from the jobsite and replaced at no additional cost.

Contractor shall be responsible to furnish pole mounting equipment that is of adequate strength and compatible for the pole it supports. This shall include but not be limited to the foundation, breakaway device, anchor rods, and hardware.

Lighting unit identification numbers shall be installed before the lighting unit is energized.

- (b) **Metal Poles.** The contractor shall avoid contact of dissimilar metals in erecting the pole on its foundation and/or breakaway device. Any concern of trapped moisture or potential corrosion cell shall be resolved to the satisfaction of the Engineer.
- (c) **Fiberglass Pole.** The depth of a direct embed fiberglass pole in the ground shall not be less than ten percent of the pole length plus 600 mm (2 ft) with a minimum of 1.8 m (6 ft). Direct embed poles shall be raked 300 mm (1 ft). Care shall be taken to get the shear plane of the pole at groundline for breakaway poles. Backfill shall be tamped and compacted around the pole in 150 mm (6 in.) layers.

830.04 Basis of Payment. This item shall be paid for at the contract unit price each for LIGHT POLE, of the type, mounting height, and arm (quantity and length) type specified.

When breakaway devices are specified the devices will be paid for separately.

SECTION 831. RESERVED

SECTION 832. RESERVED

SECTION 833. RESERVED

SECTION 834. RESERVED

SECTION 835. LIGHT TOWER

835.01 Description. This work shall consist of furnishing and installing a light tower complete with lowering device, and all appurtenances required for a complete operating unit and installing it on a concrete foundation.

835.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Light Tower	1069.04
(b) Light Pole Identification	1069.02

CONSTRUCTION REQUIREMENTS

835.03 Submittals and Certifications. Shop drawings, product data and certifications shall be submitted to the Engineer for approval. The submitted

information shall be complete and shall include information relative to all specified requirements suitable for verification of compliance.

In general, light tower submittal information shall be dated, current, project specific, identified as to the project, and shall include the following:

- (a) Dimensioned shaft drawings and details.
- (b) Shaft design calculations, including Registered Engineer Certification.
- (c) Shaft material data, including finish information.
- (d) Welding details and procedures.
- (e) Letter of intent to provide specified weld inspection reports.
- (f) Confirmation of coordination between anchor rod supplier and tower manufacturer for adequacy of anchor rod assembly.
- (g) Manufacturer's recommended installation procedures.
- (h) Letter of intent to provide manufacturer's representative during installation and to provide specified installation certification.

835.04 Shipment and Installation. The light tower, luminaire ring, etc., and hardware shall be packaged during shipment to protect all surfaces from being scratched, marred, chipped, or damaged in any way. Prior to installation, the tower and all its components will be inspected by the Engineer and any parts found to be damaged or defective shall be replaced. Any minor damage to a completely painted light tower surface shall be touched up in a professional manner as approved by the paint manufacturer.

The tower shall be set plumb on the foundation and fastened to the anchor rods with double nuts and washers. Flat washers shall be installed below and above the base plate of the pole. Locknuts with nylon or steel insert shall be installed on top of the top nut. The nuts shall be tightened in compliance with torque specifications recommended by the manufacturer of the lighting unit.

The space between the finished top of the foundation and the bottom of the base plate of the pole shall be enclosed with an expanded metal screen made of stainless steel. The size of the mesh of the screen shall be 6 mm (1/4 in.) or less and 1.22 mm (#18 gauge) thick, or heavier as approved by the Engineer. The screen shall be held in place with a stainless steel band installed around the tower base plate. The band shall be held tight by a ratchet-type device. Grouting shall not be used to enclose the above described space.

The light tower shall be straight and centered on its longitudinal axis, under no-wind conditions, so when examined with a transit from any direction, the deviation from the normal shall not exceed 2 mm in 1 m (1/8 in. in 3 ft) within any 1.5 m (5 ft) of height, with total deviation not to exceed 75 mm (3 in.) from the vertical axis through the center of the pole base.

835.05 Basis of Payment. This work will be paid for at the contract unit price each for LIGHT TOWER of the mounting heights, luminaire mounting positions and finish specified.

The concrete foundation and luminaires will be paid for according to Sections 837 and 821, respectively.

FOUNDATION AND BREAKAWAY DEVICES

SECTION 836. POLE FOUNDATION

836.01 Description. This work shall consist of furnishing and installing a light pole foundation.

836.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Reinforcement	1006.10
(c) Conduit	1088.01
(d) Anchor Rods	1070.02
(e) Metal Light Pole Foundation	1070.01
(f) Grounding for Lighting.....	1087.01

Note 1: Class SI Concrete shall be used

CONSTRUCTION REQUIREMENTS

836.03 Installation.

- (a) General. Foundations installed within the clear zone (unless behind guardrail) shall not protrude more than 100 mm (4 in.) above the finished grade within a 1.5 m (5 ft) chord across the foundation, with anchor rods and breakaway device included, according to AASHTO guidelines. If foundation heights, including anchor rods and fractured breakaway device extend beyond these specified limits, the foundation shall be replaced at the Contractor's expense.
- (b) Concrete in Ground Foundations. The foundation depths shall be as directed by the Engineer based upon evaluation of the soil conditions encountered. The Engineer may determine soil condition by visual inspection and by the use of a pocket penetrometer to establish foundation depths based upon the Foundation Depth Table or the established Foundation Table shown on the plans.

The hole for the foundation shall be made by drilling with an auger, of the same diameter as the foundation. If soil conditions require the use of a liner to form the hole, the liner shall be withdrawn as the concrete is deposited. The top of the foundation shall be constructed level. A liner or form shall be

used to produce a uniform smooth side to the top of the foundation. Foundation top shall be chamfered 20 mm (3/4 in.).

The steel reinforcement, raceway, and anchor rods shall be secured and properly positioned in the augered hole so after pouring concrete the components shall retain their proper positions.

When concrete foundations are specified, grounding electrodes shall be installed at every light pole or as shown on the plans.

The foundation form shall remain undisturbed for at least 24 hours after the concrete has been poured. The depth of the form shall be as shown on the plans. Minimum clearance from the outside edge of the foundation to any part of the pole baseplate shall be 75 mm (3 in.). The foundation depth may be reduced 150 mm (6 in.) for every 300 mm (12 in.) of rock encountered. The minimum depth of any foundation shall be 1.4 m (4.5 ft). When the foundation depth is reduced to less than 1.8 m (6 ft), the anchor rods shall be cut, threaded, and a steel plate 500 mm X 500 mm X 5 mm (20 in. X 20 in. X 1/4 in.) shall be installed on the bottom of the anchor rods 150 mm (6 in.) above the bottom of the excavated hole with 25 mm (1 in.) nuts. Anchor rod bending radius shall not be greater than four times the rod diameter. Concrete shall cure according to Article 1020.13 before lighting poles are installed.

- (c) Concrete Barrier Wall Foundations. The top portion of the foundation shall be integrated with a portion of barrier wall or barrier retaining wall, as one monolithic structure, as shown on the plans and as directed by the Engineer. This portion of the foundation shall be of the same shape as the wall. Any required sheeting, cribbing or other associated work required to complete the foundation work shall be included. The length of wall included shall be 2.4 m (8 ft).

Concrete shall be deposited against the soil. If the soil condition requires the use of a liner to form the hole, the liner shall be withdrawn as the concrete is deposited. The top of the foundation shall be constructed level.

The steel reinforcement, raceway, and anchor rods shall be secured and properly positioned in the augered hole so after pouring concrete, the components shall retain their proper positions.

Expansion couplings as detailed in the plans shall be used at the expansion joints at either end of the foundation.

- (d) Metal Foundations. The foundation shall be installed with its axis plumb. The light pole shall be installed plumb without the use of shims, grout, or other leveling devices. Metal foundations shall be installed in undisturbed soil. Predrilling a pilot hole and/or backfilling around the metal foundation is not allowed.

Any voids within the metal screw-in foundation shall be filled with fine aggregate.

Wiring slots shall be oriented to be parallel to the roadway unless otherwise directed by the Engineer to achieve alignment with grade or to minimize bends in the feeder wiring into the foundation.

The contractor shall use a torque indicating device to install metal foundations. A shear pin indicator or other Engineer approved method shall be used to insure the foundation is installed properly. A metal foundation shall not be installed to a torque which exceeds the manufacturer's maximum torque rating nor shall it be installed to an installation torque value of less than 4,750 kN m (3,500 ft lb). Metal foundations that are not installed to full installation depth or do not achieve the minimum installation torque shall be removed and replaced with a concrete foundation at no additional cost.

Driven grounding electrodes are not required when metal foundations are specified, unless otherwise indicated on the plans.

836.04 Method of Measurement.

- (a) Concrete In-Ground Foundations. The foundation will be measured for payment in meters (feet) of the foundation in place, in accordance with the total length of concrete foundation required, indicated as foundation depth, on the plans and as directed by the Engineer. Extra foundation depth, beyond the directive of the Engineer, will not be measured for payment.
- (b) Concrete Barrier Wall Foundations. The foundation will be measured for payment in meters (feet) of the foundation in place, from the bottom of the foundation to the bottom of the barrier wall as directed by the Engineer. Extra foundation depth, beyond the directive of the Engineer, will not be measured for payment.

The section of barrier wall above the foundation, including the section through the above-grade reinforcement steel, anchor rod, raceway extensions, and the grounding electrode shall be measured and paid for separately as concrete barrier wall.

- (c) Offset Foundations. The foundation will be measured for payment according to Articles 836.04(a) or 836.04(b) as applicable, except that the measurement to be taken shall be along the vertical and horizontal centerlines of the foundation without overlap.

836.05 Basis of Payment This work will be paid for at the contract unit price per meter (foot) for POLE FOUNDATION, of the type and diameter indicated, or each for POLE FOUNDATION, METAL, of the diameter, length, and bolt circle/slot indicated.

SECTION 837. LIGHT TOWER FOUNDATION

837.01 Description. This work shall consist of furnishing and installing a concrete foundation for a light tower.

837.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars	1006.10
(c) Conduit	1088.01
(d) Light Tower Anchor Rod Assembly	1070.03
(e) Grounding for lighting	1087.01

CONSTRUCTION REQUIREMENTS

837.03 General. The top of the foundation to 450 mm (18 in.) below grade shall be formed. Each foundation shall be poured monolithically. The reinforcing cage, anchor rods, and wireway shall be accurately held in place by the form. The anchor rods shall be held plumb above the top of the foundation during concrete placement.

A permanent, concrete work pad shall be constructed as indicated in the plans. This 900 mm x 900 mm x 200 mm (36 in. x 36 in. x 8 in.) pad shall be centered under the tower and level.

The anchor rod assembly may be factory fabricated with the reinforcing cage or it may be field assembled. The cage shall be hand tied, no tack welding will be allowed. Anchor rods shall sufficiently overlap with the rebar cage to develop their full holding strength. Full length anchor rods shall not be used unless approved by the Engineer.

Excess excavated material shall be disposed of by the Contractor according to Article 202.03.

The concrete shall be placed and consolidated in the foundation according to Article 503.07 and the following procedure:

The concrete shall be tremied in place and no freefall of concrete will be allowed.

Surface water will not be permitted to enter the hole and all water which may have infiltrated into the hole shall be removed before placing concrete. If dewatering of the drilled hole cannot be accomplished without loss of soil or creating quick conditions, then the hole shall be lined with a suitable steel casing before concrete is placed. The casing shall be removed from the hole as concrete is placed. The bottom of the casing shall be maintained not more than 1.5 m (5 ft) nor less than 300 mm (1 ft) below the top of the concrete during withdrawal and placing operations. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise continuously vibrating the casing.

If conditions develop that prohibit the total removal of the steel casing during concrete placement, then the foundation shall be abandoned. The Engineer will establish a new location for the foundation. The abandoned foundation and adjoining area shall be backfilled, graded, and seeded to the satisfaction of the Engineer.

As an option to this procedure, the Contractor may submit for review and approval by the Engineer alternate construction procedures according to the following parameters:

- (a) **Stay-in-Place Casing.** Install a suitable steel casing during the drilling operation, insuring continuous contact between the casing and undisturbed earth. If voids develop outside the casing, then the foundation shall be abandoned or the casing removed during concrete placement as required above.
- (b) **Concrete Placement Under Water.** Under certain soil conditions, a drilled hole containing ground water will remain stable provided the water is not removed. If this condition exists, the Contractor may propose placement of Class SC concrete according to Article 503.07 (a) to an elevation approximately 300 mm (1 ft) above the ground water elevation. At this point, the excess water shall be removed by pumping or bailing without disturbing the in-place concrete. The remaining concrete shall be placed according to Article 503.07 using Class SI concrete. The drilled hole depth shall be increased 150 mm (6 in.) to allow for laitance which may develop during the seal coat concrete placement. If the concrete being placed becomes contaminated with soil, the foundation shall be abandoned. The abandoned foundation shall be disposed of as required above.

The light tower shall not be erected until after the concrete has been cured according to Article 1020.13.

837.04 Method of Measurement. The foundation will be measured for payment in meters (feet) of light tower foundation in place.

Abandoned foundations will not be measured for payment. When the seal coat option is used, the additional 150 mm (6 in.) of foundation depth will not be measured for payment.

837.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for LIGHT TOWER FOUNDATION.

Excavation in rock will be paid for according to Section 502 for Rock Excavation for Structures.

SECTION 838. BREAKAWAY DEVICES

838.01 Description. This item shall consist of furnishing and installing a breakaway device, on a pole foundation. Breakaway devices are not required on bridge parapets, barrier walls or behind guardrail.

838.02 Materials. Materials shall be according to the following Article of Section 1000 - Materials:

Item	Article/Section
(a) Breakaway Devices	1070.04

CONSTRUCTION REQUIREMENTS**838.03 Installation.**

- (a) All entryway points created by the use of breakaway devices shall be permanently and completely sealed against rodent entry to the satisfaction of the Engineer. This includes base plate and foundation plate openings, elongated holes for anchor rods, the opening below the pole base plate and the wireway slots in the foundation. Where breakaway couplings are used in conjunction with steel foundations, the Contractor shall match the plate sizes in order to seal out rodents between the foundation and pole base.
- (b) Transformer Base. The transformer base shall be installed level and flush with the foundation without the use of washers or shims according to the manufacturer's installation procedures. All nuts, bolts, washers and lock washers required to complete the installation of the transformer base shall be included.
- (c) Breakaway Couplings. The breakaway couplings shall be coordinated to match anchor rod size. The breakaway coupling shall be installed on the anchor rod, 3.2 mm to 9.5 mm (1/8 to 3/8 in.) above the top of the foundation according to the manufacturer's recommendations. The coupling installation shall not be used to level the pole base in lieu of a level foundation.

838.04 Basis of Payment. This item will be paid at the contract unit price each for BREAKAWAY DEVICE, TRANSFORMER BASE, of the bolt circle indicated; BREAKAWAY DEVICE, COUPLING WITH ALUMINUM SKIRT, WITH FIBERGLASS SHROUD, or WITH STAINLESS STEEL SCREEN..

Breakaway couplings will be paid for individually, not as a set of four. Aluminum skirt and fiberglass shroud are not to be installed on weathering steel poles.

The foundation will be paid for according to Section 836.

SECTION 839. RESERVED**SECTION 840. RESERVED****REMOVAL, RELOCATION, AND TEMPORARY LIGHTING****SECTION 841. TEMPORARY LIGHTING REMOVAL**

841.01 Description. This item shall consist of the disconnection and removal of the temporary lighting system.

CONSTRUCTION REQUIREMENTS

841.02 Removal. Removal shall include the removal of temporary poles (which may be either wood, concrete, steel, or aluminum), aerial cable and all associated apparatus, and connections. This removal shall include removal of all wiring and connections to the associated lighting controller. All equipment and material except for luminaires removed as part of this item shall become property of the Contractor and shall be removed from the site.

All luminaires shall be inspected by the Engineer. Non-operating or damaged luminaires shall be repaired or replaced in kind by the Contractor.

Luminaires shall be removed, boxed in new containers approved by the Engineer and delivered and unloaded at a storage facility of the Owner, as designated by the Engineer.

Pole holes shall be backfilled according to Section 815.

With the approval of the Engineer, the Contractor may partially remove the temporary lighting system after parts of the permanent lighting system are operational. Any modifications to the temporary system to keep the temporary lighting system and permanent lighting system operational shall be at the Contractor's expense.

841.03 Method of Measurement. Units measured for payment will be counted on a per-pole basis, regardless of pole material, mounting height, the number and type of mast arm(s), luminaires and other appurtenant items attached thereto.

841.04 Basis of Payment. This work will be paid for at the contract unit price each for REMOVAL OF TEMPORARY LIGHTING UNIT.

SECTION 842. REMOVAL OF LIGHTING UNITS

842.01 Description. This work shall consist of the removal and disposal of existing light pole foundation, breakaway device, pole, arm(s), luminaire(s), wire, hardware, and all associated appurtenances, including the backfilling of the excavated areas.

CONSTRUCTION REQUIREMENTS

842.02 General. Any damage resulting from the removal and/or transportation of the lighting luminaire and associated hardware, shall be repaired or replaced in kind, at the Contractor's expense, to the satisfaction of the Engineer. The Engineer will be the sole judge to determine the extent of damage and the suitability of repair and/or replacement.

No removal work shall be permitted without approval from the Engineer. Abandoned underground electric cables shall be removed with conduit and duct to a depth of 300 mm (1 ft) below ground level and the hole shall be backfilled. Cables in unit duct may be removed from the duct and become property of the Contractor. The

empty duct shall be removed to 300 mm (1 ft) below ground level and the hole backfilled.

Any pole removal shall start as soon as the temporary lighting or permanent lighting, as applicable, is placed in approved operation. An inspection and approval by the Engineer will take place before any associated proposed permanent or temporary lighting is approved for operation.

The removal of underpass and sign luminaires shall include all associated conduit, wire, junction boxes, hardware, and appurtenances.

842.03 Removal of Lighting Unit, No Salvage. When indicated, poles, mast arms, luminaires, and all associated hardware and appurtenances shall become the property of the Contractor and shall be disposed of off the project site.

842.04 Removal of Lighting Unit, Salvage. When indicated, poles, mast arms, luminaires, and all associated hardware and appurtenances shall remain the property of the Owner and shall be delivered to an Owner's facility within the District and unloaded and stacked there, as directed by the Engineer. Wood blocking, banding or other appurtenant items required for proper stacking and protection shall be included.

Luminaires shall be removed, boxed in new containers approved by the Engineer and delivered and unloaded at an owner's storage facility, as designated by the Engineer.

842.05 Removal of Pole Foundation. Concrete foundations shall be removed to at least 600 mm (2 ft) below grade with removed material disposed of off the site. The removal shall extend deeper where required to facilitate roadway construction at no additional cost. Underground conduits and cables shall be separated from the foundation at 750 mm (2.5 ft) below grade and shall be abandoned or re-used as indicated.

Where light poles are removed from retaining or parapet walls, the Contractor shall cut off the anchor rods and conduit stub-ups 25 mm (1 in.) below the wall surface and fill all voids with portland cement concrete mortar with curing compound making a smooth surface to match the shape of the wall.

Existing steel helix foundations shall be removed and cleaned to expose the foundation for inspection by the Engineer. Those foundations deemed not reusable by the Engineer shall become the property of the Contractor and shall be disposed of off the right of way. Those foundations deemed re-usable by the Engineer shall be delivered to an Owner's storage facility and unloaded and stacked there as directed by the Engineer.

The void caused by the removal of the foundations shall be backfilled with trench backfill according to Section 815.

842.06 Method of Measurement. Each lighting unit (pole, mast arm, luminaire, and appurtenant equipment) which is removed and delivered to the Owner's storage or disposed of as indicated, shall be counted as a unit for payment.

Removal of the existing underpass luminaire shall be measured by the unit price per each underpass luminaire removed.

Removal of the existing sign luminaire shall be measured by the unit price per each sign luminaire removed.

Foundation removal shall be measured as each.

842.07 Basis of Payment. This work will be paid for at the contract unit price each for REMOVAL OF LIGHTING UNIT, SALVAGE; or REMOVAL OF LIGHTING UNIT, NO SALVAGE; REMOVAL OF POLE FOUNDATION of the type specified.

SECTION 843. REMOVAL OF NAVIGATION OBSTRUCTION WARNING LIGHTING SYSTEM

843.01 Description. This work shall consist of removing the existing bridge navigation obstruction lighting system. This navigation lighting system shall include fixtures installed for river navigation and where applicable fixtures installed for air navigation.

CONSTRUCTION REQUIREMENTS

843.02 General. Any damage resulting from the removal and/or transportation of the lighting fixtures and associated hardware, shall be repaired or replaced in kind, at the Contractor's expense, to the satisfaction of the Engineer. The Engineer will determine the extent of damage and the suitability of repair and/or replacement.

No removal work shall be permitted without approval from the Engineer. When the underground electric cables shall be abandoned, 300 mm (1 ft) below ground level shall be cut. Cables in unit duct may be removed from the duct and may become property of the Contractor. Duct shall be abandoned and cut 300 mm (1 ft) below ground level.

Navigation lighting must remain operational throughout the project in accordance with FAA and Coast Guard requirements and as directed by the Engineer. An inspection and approval by the Engineer will take place before any proposed permanent or temporary lighting is approved for operation. Navigation lighting units and all associated hardware and appurtenances, (including conduit and cable) shall become the property of the Contractor and shall be disposed of off the project site.

843.03 Removal of Electric Service and Lighting Controller. The existing electric service and navigation obstruction lighting controller shall be removed and disposed of as directed by the Engineer.

843.04 Removal of Navigation Obstruction Fixtures. Existing fixtures to be removed shall include the fixture, fixture housing, mounting devices, flanges, nipples, relay boxes, junction boxes, support arms and arm lifting devices, counter balance and weights, wiring and electrical devices, and all other fixture appurtenances as directed by the Engineer. Any fixtures or fixture components which the Engineer designates as salvage, shall be removed, boxed in new containers approved by the

Engineer and delivered and unloaded at a storage facility of the owner, as designated by the Engineer. Wood blocking, banding or other appurtenant items required for proper stacking shall be included.

843.05 Removal of Conduit attached to Structure. Conduit hangers, straps and supports shall be removed from bridge steel as directed by the Engineer. All open conductors and porcelain insulators shall be removed with the conduit system. Where the conduit system is removed from parapet walls and other concrete surfaces, the Contractor shall cut off the anchor device 25 mm (1 in.) below the surface of the concrete and fill all voids with portland cement concrete mortar with curing compound making a smooth finish to the concrete surface.

Unprotected bridge steel which is exposed by the removal of the conduit system shall be touched up by the Contractor using a paint and procedure approved by the Engineer. Minor repairs to concrete and bridge steel as detailed above shall be made by the Contractor at no additional cost.

843.06 Basis of Payment. This work will be paid for at the contract unit price each for REMOVAL OF NAVIGATION OBSTRUCTION WARNING LIGHTING SYSTEM.

SECTION 844. RELOCATE LIGHTING UNITS AND POLES

844.01 Description. This item shall consist of removing an existing lighting unit and reinstalling temporary poles and/or lighting unit on a proposed foundation in locations as designated by the Engineer.

844.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Pole/Unit Identification	1069.02
(b) Fuseholders & Fuses	1065.01

CONSTRUCTION REQUIREMENTS

844.03 Lighting Unit.

- (a) Removal. The existing lighting unit shall be disconnected and removed from the existing foundation by removing the anchor rod nuts and lifting the lighting unit from the foundation.

Any damage sustained to the lighting unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer at the Contractor's expense.

- (b) Reinstallation. The lighting unit shall be installed immediately on the proposed foundation. The electric cables shall be connected to power supply cables so the reinstalled lighting unit becomes operational the same evening without interruption. Temporary wiring will be permitted at the discretion of the Engineer.

When a conduit or duct extension is required, the conduit and/or duct may be spliced and a new span of cable shall be installed. The Engineer will inspect all conduit and/or duct splices before backfilling.

The existing pole wire shall be preserved and reconnected to the proposed underground wiring. The space between the finished top of the foundation and the base plate of the pole shall be enclosed to prevent the entry of rodents in a manner approved by the Engineer.

The anchor rod cover and handhole covers of the lighting unit shall be removed and reinstalled. If during removal, the screws holding the cover break, a hole in the pole base shall be drilled and threaded to accept a new screw. The screws shall be 6 mm (1/4 in.) 20 stainless steel with anti-seize compound applied.

The mast arm and/or luminaire may be removed and reinstalled as a unit, at the option of the Contractor, with the approval of the Engineer. No additional compensation will be paid for these operations.

Luminaire Circuit Identification. Each lighting unit which is to be relocated under this item shall be checked during the preconstruction inspection for complete circuit identification. Any damage to the identification occurring prior to final acceptance shall then be repaired or replaced under this item, in conformance with the specifications, at no additional cost to the Contract. The existing circuit identification and the identification shown on the Plans shall be compared and where the existing identification must be changed to conform with the Plans, the removal and replacement of identification shall be included in this item.

844.04 Light Towers. The space between the finished top of the foundation and the bottom of the base plate of the pole shall be enclosed with an expanded metal screen made of stainless steel. The mesh of the screen shall be 6 mm (1/4 in.) or less as approved by the Engineer. The screen shall be held in place with bands made of stainless steel. The ends shall be held tight by a ratchet-type device. Grouting shall not be used to enclose the above described space.

The light pole shall be straight and centered on its longitudinal axis, under no-wind conditions, so, when examined with a transit from any direction, the deviation from the normal shall not exceed 3 mm (1/8 in.) within any 1.5 m (5 ft) of height, with total deviation not to exceed 75 mm (3 in.) from the vertical axis through the center of the pole base.

844.05 Temporary Wood Poles.

- (a) **Removal and Reinstallation.** The temporary lighting unit shall be installed immediately at the new location. The electric cables shall be connected to power supply cables so the reinstalled temporary light unit becomes operational the same evening without interruption. If the existing electric cables are not of sufficient length to make the new connection, a new continuous span of electric cables, of equal or better quality, shall be installed at no additional cost.

Any damage sustained to the temporary light unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer at the Contractor's expense.

- (b) **Luminaire Circuit Identification.** Each pole which is to be relocated shall be checked during the preconstruction inspection for complete circuit identification and corrected as stated in Article 1069.02.

Any damage to the identification occurring prior to final acceptance shall be repaired or replaced by the Contractor according to the specifications at no additional cost to the Department.

844.06 Method of Measurement. When a temporary lighting unit or pole is in conflict with the proposed construction, then the Engineer will authorize the Contractor to relocate the temporary lighting unit and be paid for the relocation.

When a temporary lighting unit or pole is not in conflict with the proposed construction, but is in conflict with the Contractor's proposed sequence of operations, or the relocation is for the Contractor's convenience, relocation of said temporary lighting unit will be at the Contractor's option and expense. The Contractor shall obtain the Engineer's approval before any pole or unit is relocated.

If the Engineer determines a given temporary lighting unit's pole setting has deteriorated to such an extent that the pole poses a safety hazard, the temporary lighting unit may be reset in or near the same location. Resetting of the pole will not be paid for if the pole setting has been weakened by construction operations. Resetting of the pole will be paid for if the setting has been weakened due to natural occurrences, (i.e. rain storms). In all cases the Engineer will determine if the relocation is or is not at Contractor's expense.

844.07 Basis of Payment. This work will be paid for at the contract unit price each for RELOCATE EXISTING LIGHTING UNIT of the type indicated; or RELOCATE EXISTING LIGHT TOWER or RELOCATE EXISTING TEMPORARY POLES.

SECTION 845. REMOVAL OF LIGHTING CONTROLLER

845.01 Description. This work shall consist of the removal and disposal of existing electric service installation, lighting controller, and associated foundations, and all associated appurtenances, including the backfilling of the excavated areas.

CONSTRUCTION REQUIREMENTS

845.02 General. No removal work shall be permitted without approval from the Engineer. Abandoned underground electric cables shall be removed with conduit and duct to a depth of 300 mm (1 ft) below ground level and the hole backfilled. Cables in unit duct may be removed from the duct and become property of the Contractor.

Any removal work involving facilities owned by the electric utility shall be coordinated by the Contractor to insure the utility is properly notified and (if necessary) present while the removal work is being done. The Contractor shall

insure that the removal work is disconnected from the utility's service equipment in a manner which is in compliance with the requirements of the utility.

845.03 Removal of Electric Service Installation. This work shall consist of the removal and satisfactory disposal of the wood pole and weatherhead or underground pedestal, grounding electrode, meter base, disconnect, conduit, wiring, and other miscellaneous items associated with an electric service installation, according to applicable portions of Section 804.

845.04 Removal of Lighting Controller. This work shall consist of the removal and satisfactory disposal of the lighting controller cabinet, enclosed electrical equipment, and all other miscellaneous items associated with a lighting controller, according to applicable portions of Section 825.

845.05 Removal of Lighting Controller Foundation. Concrete foundations shall be removed to at least 600 mm (2 ft) below grade with removed material disposed of off the site. The removal shall extend deeper where required to facilitate roadway construction at no additional cost. Underground conduits and cables shall be separated from the foundation at 750 mm (2.5 ft) below grade and shall be abandoned or re-used as indicated. The grounding electrode shall be removed or cut off to the same depth as the concrete.

Existing steel helix foundations shall be removed and cleaned to expose the foundation for inspection by the Engineer. Those foundations deemed not reusable by the Engineer shall become the property of the Contractor and shall be disposed of off the right of way. Those foundations deemed re-usable by the Engineer shall be delivered to an Owner's storage facility and unloaded and stacked there as directed by the Engineer.

The void caused by the removal of the foundations shall be backfilled with trench backfill according to Section 815.

845.06 Method of Measurement. Each lighting controller (with foundation and electric service) which is removed and disposed of as indicated, will be counted as a unit for payment.

Foundation removal will be measured as each.

Electric Service Installation removal will be measured as each.

845.07 Basis of Payment. This work will be paid for at the contract unit price each for REMOVAL OF LIGHTING CONTROLLER; or REMOVAL OF ELECTRIC SERVICE INSTALLATION; or REMOVAL OF LIGHTING CONTROLLER FOUNDATION.

SECTION 846. RESERVED

SECTION 847. RESERVED

SECTION 848. RESERVED

SECTION 849. RESERVED**SIGNAL MAINTENANCE****SECTION 850. MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION**

850.01 Description. This work shall consist of maintaining an existing traffic signal installation that has been designated to remain in operation during construction.

850.02 Procedure. The energy charges for the operation of the traffic signals will be paid for by the Department or the local agency.

At least one week prior to beginning construction within 125 m (400 ft) of the signalized intersection, the Contractor shall conduct a signal inspection with a representative of the agency responsible for the signal maintenance. The signal inspection shall reveal defective existing traffic signal items such as inductive loop detectors, lead-in cable, detector loop, interconnect cable and so forth, and the Contractor shall not be held responsible for these items. In case the Contractor fails to contact the signal maintaining agency for the signal inspection, the Contractor shall be held responsible for all the signal items remaining defective at the completion of the construction.

The Contractor shall become responsible for the maintenance of the existing signalized intersection at a date mutually agreed upon between the Contractor and the signal maintaining agency representative but no later than the beginning of construction by the Contractor within 125 m (400 ft) of the intersection. The Contractor's signal maintenance responsibility shall cease upon the issuance of a Signal Acceptance Notice by the Engineer.

850.03 Maintenance. The maintenance shall be according to Article 802.07 and the following:

The Contractor shall be responsible for the controller programming to provide for safe and efficient signal operation during construction. The Contractor may seek assistance from the maintaining agency personnel on the appropriate controller settings.

850.04 Basis of Payment. This work will be paid for at the contract unit price per each for MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

SECTION 851. PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT

851.01 Description. This work shall consist of cleaning and painting the existing traffic signal equipment reused as part of the new traffic signal installation.

851.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Traffic Signal Paint	1071.01

CONSTRUCTION REQUIREMENTS

851.03 Cleaning. Prior to painting, the surfaces shall be thoroughly cleaned of all surface irregularities and foreign materials, so the prime and paint coatings will have a smooth finish.

851.04 Painting. After cleaning, one coat of an approved primer shall be applied to all areas where the old paint has been removed or damaged. On surfaces where small areas of metal at closely spaced intervals are exposed, the primer shall consist of a complete coating. The surface of the signal equipment shall be painted as follows:

- (a) The signal housings, controller cabinet, signal posts (except bright aluminum posts) and brackets shall be painted with two coats of yellow enamel.
- (b) The signal doors, visors, and metal backplates shall be painted with two coats of dull (matte) black paint.
- (c) The steel mast arm assemblies and poles shall be painted with two coats of aluminum paint, when specified on the plans.

851.05 Basis of Payment. This work will be paid for at the contract unit price for each intersection as PAINT EXISTING TRAFFIC CONTROL EQUIPMENT.

SECTION 852. RESERVED

SECTION 853. RESERVED

SECTION 854. RESERVED

SECTION 855. RESERVED

SECTION 856. RESERVED

CONTROLLERS

SECTION 857. TRAFFIC ACTUATED CONTROLLER

857.01 Description. This work shall consist of furnishing and installing a traffic actuated solid state digital controller in the controller cabinet of the type specified with peripheral equipment.

857.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Traffic Actuated Solid State Digital Controller	1073.01
(b) Controller Cabinet and Peripheral Equipment	1074.03

CONSTRUCTION REQUIREMENTS

857.03 Installation. The traffic actuated controller shall be installed in a completely wired cabinet, with necessary connections for proper operation. The model and serial number of the controller shall be permanently affixed on the front or top of the controller housing and readily visible.

All conduit entrances into the controller cabinet shall be sealed with a pliable waterproof material. Electrical cables inside the controller cabinet shall be neatly trained along the base and back of the cabinet. Each conductor shall be connected individually to the proper terminal, and the spare conductors shall be insulated and bound into a neat bundle. Each cable shall be marked with identification meeting the approval of the Engineer and recorded on a copy of the plans for the intersection and submitted to the Engineer.

The traffic actuated controller shall provide the NEMA eight phase dual ring operation for the phase designation diagram shown on the plans and the preemption sequence of operation, when shown on the plans. A print out of all controller settings including coordination and preemption shall be provided to the Engineer.

857.04 Basis of Payment. This work will be paid for at the contract unit price each for FULL-ACTUATED CONTROLLER AND CABINET of the type specified, which price shall include the conflict monitor, load switches, and flasher relays. The transceiver shall be furnished with the controller only when specified as a separate pay item on the plans.

SECTION 858. FLASHER CONTROLLER

858.01 Description. This work shall consist of furnishing and installing a flasher controller and cabinet.

858.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Flasher Controller	1073.02

CONSTRUCTION REQUIREMENTS

858.03 Installation. The flasher controller shall be installed according to the details shown on the plans.

858.04 Basis of Payment. This work will be paid for at the contract unit price each for FLASHER CONTROLLER.

SECTION 859. TRANSCEIVER

859.01 Description. This work shall consist of furnishing and installing a transceiver with necessary connections for proper operation.

859.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Transceiver	1073.03

CONSTRUCTION REQUIREMENTS

859.03 Installation. The transceiver shall be connected to the communication interface panel. The transceiver shall be assigned a unique address in the master controller.

859.04 Basis of Payment. This work will be paid for at the contract unit price each for TRANSCEIVER.

The interface panel, all necessary harnesses, and the programming of the controller and the master controller shall be included in this item.

SECTION 860. MASTER CONTROLLER

860.01 Description. This work shall consist of furnishing and installing a master controller with the necessary connections for proper operation.

860.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Master Controller	1073.04

CONSTRUCTION REQUIREMENTS

860.03 Installation

- (a) Telephone Service. The Contractor shall arrange with the telephone company to install a standard voice-grade dial-up telephone line. Any charges by the telephone company to provide initial service will be paid for according to Article 109.05.
- (b) System Set-up. The Contractor shall set up graphic displays and all software parameters, including compatible viewing and control capabilities from the remote monitor.
- (c) Housing and Cabinet. The model and serial numbers shall be affixed on the front of the housing and shall be readily visible. The master controller shall be installed in the same cabinet with a traffic signal controller. One circuit breaker rated at 10 A shall be provided.
- (d) Software. Based on the need, up to three complete sets of the latest edition of registered remote monitoring software with full manufacturer's support shall be furnished with each master controller. Each set shall consist of complete software on 90 mm (3 1/2 in.) floppy disks, and a bound set of manuals containing loading and operating instructions. The distribution of the software will be directed by the Engineer.

860.04 Basis of Payment. This work will be paid for at the contract unit price each for MASTER CONTROLLER.

CONTROL EQUIPMENT

SECTION 861. DIGITAL TIME SWITCH

861.01 Description. This item shall consist of furnishing, installing, and setting a digital time switch, with necessary connections for proper operation.

861.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Digital Time Switch	1074.01

861.03 Basis of Payment. This work will be paid for at the contract unit price each for DIGITAL TIME SWITCH.

SECTION 862. RESERVED

SECTION 863. CONTROLLER CABINET AND PERIPHERAL EQUIPMENT

863.01 Description. This work shall consist of furnishing and installing a cabinet and peripheral equipment for an existing traffic signal controller.

863.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Controller Cabinet and Peripheral Equipment	1074.03

CONSTRUCTION REQUIREMENTS

863.03 General. The cabinet shall be furnished with panel, terminal facilities, conflict monitor, load switches, and flasher relays complete with necessary connections for proper operation. The type of cabinet shall be as specified on the plans.

863.04 Basis of Payment. This work will be paid for at the contract unit price each for CONTROLLER CABINET of the type specified.

SECTION 864. TRANSCEIVER-FIBER OPTIC

864.01 Description. This work shall consist of furnishing and installing a fiber optic transceiver for a traffic signal controller.

CONSTRUCTION REQUIREMENTS

864.02 General. The fiber optic transceiver shall be installed according to Section 859 and the following:

All fiber optic components except the interconnect cable itself, required to provide proper communication between local controllers and/or masters, shall be furnished and installed as part of this item.

864.03 Transceiver Components. The transceiver and all related components and connections shall be provided for the proper operation of the fiber optic interconnect communication system in each traffic signal cabinet. These items shall include but not be limited to the following:

- (a) Distribution Enclosure. Field cable shall terminate in the controller cabinet within a wall-mount distribution enclosure. The distribution enclosure shall seal out dust and moisture. The size shall be sufficient to store all fiber windings and splices. The location of the distribution enclosure shall not restrict access to other controller components. The field cable shall be firmly secured to the enclosure with hose clamps or similar clamping devices. The cabinet cable shall leave the enclosure through rubber grommets or similar devices to protect the cable against wear. The field cable jacket shall be removed and all protective gel cleaned from the loose tubes as recommended by the cable supplier. Sufficient lengths of every loose tube shall be coiled within the enclosure to reach the fiber interface panel or modem.

- (b) Connectors. Only ST type connectors of ceramic ferrule and Physical Contact (PC) end finish shall be used to terminate fibers to equipment. ST or mechanical connectors shall not be used to splice cables.
- (c) Splices. The fiber cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices will be allowed outside the controller cabinets. Only mechanical or fusion splices will be allowed in the controller cabinet. The splices shall be secured in a splice organizer tray.
- (d) Modems and Power Source. Communication between local controllers and the system master controllers shall be facilitated by the use of fiber optic modems. The modems shall be capable of communications with NEMA traffic signal controllers in a coordinated closed loop system. Modems shall be active devices providing full-duplex communication via RS-232 connector and supporting daisy-chain wiring. The nominal operating wavelength shall be 850 nm. The modems shall be according to NEMA Standards for Traffic Control Systems, TS1, Section 2. A minimum of two fiber optic ports shall be provided on each modem. Each fiber optic port shall be ST-PC style and shall be identified as either transmitter or receptor of the optic signal. The other end of the modem shall have the male type RS-232 connector. The modems shall be installed on the interface panel on the side of the controller cabinet. The modems shall be powered from the controller telemetry module.
- (e) Light Source. An LED light source with a wavelength that is the system wavelength shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber in both numerical aperture (NA) and core diameter.
- (f) Power Meter. The detector in the power meter shall have an effective NA and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 dBm to -40 dBm. The power meter shall have an accuracy of ± 0.5 dB through the operating temperature and minimum resolution of 0.1 dB.
- (g) Breakout Kits. Breakout kits shall provide for the separation and protection of individual fibers with buffer tubing and jacketing materials suitable for termination of the fiber with the fiber optic connectors as specified.
- (h) Interface Panel. This panel interfaces the controller telemetry to the fiber optic modems and provides terminal block tie points for the other telemetry signals. A terminal for each conductor in the cable shall be required.

864.04 Testing and Product Information. Field testing of the equipment shall be according to Article 802.08(b). All components of the fiber optic system shall have the manufacturer's name, address, type, style, model or serial number, and catalog number on a plate secured to the equipment. It is advised that the system be of the same manufacture to assure uniformity, interchangeability of components, single responsibility, and most satisfactory service.

864.05 Basis of Payment. This work will be paid for at the contract unit price each for TRANSCEIVER - FIBER OPTIC, for each traffic signal cabinet.

WIREWAY AND CONDUIT SYSTEM

SECTION 866. GULFBOX JUNCTION

866.01 Description. This item shall consist of furnishing and installing a gulfbox junction.

866.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Cast Iron Box	1075.01
(b) Composite Concrete Box	1075.01

CONSTRUCTION REQUIREMENTS

866.03 Installation. The top of the gulfbox shall be set flush with the sidewalk or a paved surface. When installed in earth shoulder away from the pavement edge, the top surface of the gulfbox shall be 25 mm (1 in.) above the finished grade.

When the gulfbox is to be constructed over existing conduit, the conduit shall be cut 90 degree elbows installed, and the box constructed as detailed in the plans.

- (a) Cast Iron Gulfbox. The installation shall consist of pouring Class SI Concrete around the conduits to a level 190 mm (7 1/2 in.) below the surrounding grade with dimensions as shown in the plans. The conduits shall protrude approximately 15 mm (1/2 in.) above the concrete surface. The casting shall be secured by setting the bottom flange into the concrete surface 12 to 20 mm (1/2 to 3/4 in.) while the concrete is still plastic and then trowel the surface smooth. Any piping slots in the sides shall be suitably plugged.
- (b) Composite Concrete Gulfbox. Installation of the composite concrete box shall consist of placing CA 6 granular material around the conduits to a depth of 300 mm (12 in.) below the surrounding grade. The conduits shall protrude approximately 25 mm (1 in.) above the granular material. The box shall be set on this base and surrounded by an additional CA 6 granular material to the concrete collar shown in the plans.

866.04 Basis of Payment. This work will be paid for at the contract unit price each for GULFBOX JUNCTION and of the kind of material when specified.

No additional compensation will be allowed for constructing the gulfbox on existing conduits.

SECTION 867. PULLING PEDESTAL

867.01 Description. The work shall consist of furnishing and installing a pulling pedestal complete.

867.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Pulling Pedestal	1075.02
(b) Concrete (Note 1)	1020

Note 1: Class SI concrete shall be used.

CONSTRUCTION REQUIREMENTS

867.03 General. Concrete shall be cast in place. The pulling pedestal assembly shall be anchored to the concrete foundation as shown on the plans. The pulling pedestal enclosure shall be mounted atop an enclosure base constructed from the same materials as the cabinet and of the same cross-section as the cabinet. The base extension shall be painted as specified for the cabinet. The foundation shall extend 300 mm (12 in.) above ground.

Except where the pulling pedestal is facing a sidewalk, a poured 100 mm (4 in.) thick concrete pad, not less than 600 mm (48 in.) square, shall be provided in front of the cabinet.

Where a pulling pedestal is contiguous to a sidewalk, preformed joint filler of 13 mm (1/2 in.) thickness be placed between the pulling pedestal and the sidewalk.

867.04 Grounding. The pulling pedestal shall be grounded according to Article 1087.02.

867.05 Basis of Payment. This work will be paid for at the contract unit price each for PULLING PEDESTAL, of the size specified. The cost of the ground rod will be included in the cost of the pulling pedestal.

WIRE AND CABLE**SECTION 870. MULTI-CONDUCTOR POWER CABLE**

870.01 Description. This work shall consist of furnishing and installing multi-conductor direct burial power cable, complete with all splicing, identifications and terminations.

870.02 Materials. Materials shall meet the requirements of the following Article Section 1000 - Materials:

Item	Article/Section
(a) Multi-Conductor Power Cable	1076.01

CONSTRUCTION REQUIREMENTS

870.03 Installation.

- (a) General. The multi-conductor cable extended to equipment shall be of a length sufficient for cable splices to be withdrawn a minimum of 450 mm (18 in.) out of pole handholes, pull boxes, or junction boxes.

For preparation of cable termination or splicing, the multi-conductor cable jacket and any underlying tape, shall be removed for a distance of 200 mm (8 in.) from the end of the center conductor. The fillers shall be removed and cut at the end of the jacket. The assembly shall be taped tightly together at the end of the jacket before the conductors are spread apart.

Multi-conductor cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. No underground splicing of cable will be permitted.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

Splices and terminations shall be according to Article 1066.06. The multi-conductor cable assembly shall be terminated with a multi-leg heat-shrink boot. The end of the cable shall be wrapped with sealant tape recommended by the boot manufacturer around and between individual insulated conductors, with the boot overall. The boot shall meet military specification Mil 1-81765/1.

- (b) In Trench. The cable shall be installed as indicated on the plans and according to the manufacturer's recommendations. Installation, after inspection by the Engineer, shall be backfilled according to Section 815, except plowing will not be allowed.
- (c) In Raceway. Raceways shall be cleaned and freed of rough spots by reaming or other methods approved by the Engineer. All raceways shall be swabbed and blown clean with compressed air. Lubricating compounds approved by the cable manufacturer shall be used to facilitate installation of the cable in raceways.

The manufacturer's recommended allowable tension for the conductor or the allowable sidewall load, whichever is smaller, shall be used for maximum pulling tension. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

870.04 Method of Measurement. The cable will be measured for payment in meters (feet) in place. Measurements will be made in straight lines between changes

in direction and to the centers of equipment and box access points. 3 m (10 ft) will be allowed when terminating cable at a controller. 1 m (3 ft) of slack will be allowed at light pole, handholes, pull boxes, junction boxes, and similar locations.

Vertical cable will be measured for payment. The vertical distance required for breakaway devices, barrier walls, concrete pedestals, etc., and the depth of any burial will be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

870.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for ELECTRIC CABLE ASSEMBLY IN CONDUIT, or TRENCH, 600V of the type, size, and number of conductors indicated.

SECTION 871. FIBER OPTIC CABLE

871.01 Description. This work shall consist of furnishing and installing all accessories required and the fiber optic cable of the type, size and number of fibers specified.

871.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Fiber Optic Cable	1076.02

871.03 Contractor Qualifications. The fiber optic cable installation shall be supervised by trained and experienced personnel. The cable terminations and splices shall be made by qualified technicians. Upon request by the Engineer, the Contractor shall provide documentation on qualifications and experience for fiber optic equipment installations. The Engineer will determine if the Contractor is qualified to perform the work.

CONSTRUCTION REQUIREMENTS

871.04 Cable Installation.

- (a) General. The fiber optic cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices shall be allowed outside the controller cabinet. The cable end shall be secured inside the controller cabinet so no load is applied to the exposed fiber strands.
- (1) Cable Minimum Bend Radius. For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than 15 times the diameter of the cable outside diameter or as recommended by the manufacturer.
- (2) Cable Slack. Slack cable shall be left in each handhole and double handhole, at the top of each conduit riser, and at each wood support pole according to the following requirements. Storage of additional slack cable in each handhole shall be coiled. These slack coils shall be bound at a minimum of three points around the coil perimeter and

supported in their static storage positions. Storage of additional slack cable adjacent to conduit risers and support poles shall be as detailed on the plans. The minimum slack amounts shall be as follows.

<u>Slack Location</u>	<u>Slack Cable Length</u>	
	meters	feet
Gulfbox	0.5	1.5
Junction Box	0.5	1.5
Handhole	2.0	6.5
Double Handhole	4.0	13.0
Conduit Riser	4.0	13.0
Support Pole	4.0	13.0

- (3) Cable Termination. Field cable shall terminate in the controller cabinet within a wall-mounted distribution enclosure according to Article 864.03.
- (b) Installation in Conduits and Ducts. A suitable cable feeder guide shall be used between the cable reel and the face of the conduit/duct to protect the cable and to guide it into the conduit off the reel. The cable shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer shall be notified.

Precautions shall be taken during installation to prevent the cable from being kinked or crushed. A pulling eye shall be attached to the cable and used to pull the cable through the conduit. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be lubricated with a type of lubricant recommended by the cable manufacturer. The lubricant used shall be of water based type and approved by the cable manufacturer. Dynamometers or break away pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension specified by the cable manufacturer. Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of the cable shall be hand assisted at each controller cabinet. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination. At the controller cabinet and at the handhole the cable shall be visibly marked/tagged as "CAUTION-FIBER OPTIC CABLE".

- (c) Installation on Aerial Spans. The fiber cable shall be lashed onto the aerial support span wire. The aerial support shall be existing span wire, or new span wire according to Section 872. When the existing interconnect is supported by messenger cable and hanger rings, the rings and interconnect cable shall be removed. Existing conduit risers designated for re-use with the fiber optic interconnect shall have the existing weatherhead removed. Removal of these items shall be included in the cost of the fiber optic cable. The fiber optic cable shall be secured to the support cable by lashing with a cable lasher. The lashing wire shall be a dielectric lashing filament to prevent the conductance or attraction of lightning. The lashing wire shall be securely tied off when terminated near each support pole.

- (d) Cable Placement into Conduit Risers. Kellum grips and/or other hanger devices shall be used to support the vertical drop of the cable and to prevent any possible kinking of the cable after installation. The top of the risers shall have a hexnut type watertight service entrance connector with an oval shaped grommet. The grommet shall be either neoprene or rubber. The voids between the fiber optic cable(s) and the grommet shall be sealed with silicone.

The fiber optic cable shall be tested according to Article 802.08(b).

871.05 Method of Measurement. Cable will be measured for payment in meters (feet) in place. Cable will be measured horizontally and vertically between the changes in direction, including slack cables and the cable in the vertical conduit riser. The cable length in the foundations of a controller cabinet and a vertical pole will be accounted as 1 m (3 ft) each.

871.06 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for FIBER OPTIC CABLE of the type, size, and number of fibers specified.

The lengths of slack cable allowed and the vertical cable in the foundations and the cable in the vertical conduit riser will be paid for at the contract unit price per meter (foot) for FIBER OPTIC CABLE IN CONDUIT. The length of the cable on aerial span will be paid for at the contract unit price per meter (foot) for FIBER OPTIC CABLE ON MESSENGER.

The type specified will indicate whether the cable is installed in conduit or on messenger. The cable warning tags will be included in the cost of the fiber optic cable.

SECTION 872. SPAN WIRE AND TETHER WIRE

872.01 Description. This work shall consist of furnishing and installing span wire or tether wire and accessories.

872.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Span Wire and Tether Wire	1076.03

CONSTRUCTION REQUIREMENTS

872.03 Installation. The span wire or tether wire with accessories shall be installed according to the details shown on the plans.

872.04 Method of Measurement. Span wire and tether wire will be measured for payment in meters (feet) in place. Measurements will be along the horizontal distances between the supporting poles.

872.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for SPAN WIRE or TETHER WIRE.

Any additional span wire or tether wire required for sag and wrap around shall be included in the cost of the wire specified.

SECTION 873. ELECTRIC CABLE

873.01 Description. This work shall consist of furnishing and installing an electric cable of the type, size, and number of conductors specified.

873.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Electric Cable - Signal, Lead-in, Communication, and Service	1076.04
(b) Conduit	1088.01

CONSTRUCTION REQUIREMENTS

873.03 Installation. The electric cable may be installed in a trench, in a conduit, or aerially suspended, as indicated on the plans. When installed in a trench, the electric cable shall have a minimum depth of 750 mm (2.5 ft) or 600 mm (2 ft) as indicated on the plans.

The color coded conductor shall be connected according to the following schedule:

(a) Signal Cable - Signal Head (5 Conductor or 7 Conductor)

Conductor No.	Base Color	Tracer Color	Connection
1	Black		
2	White		AC, Neutral
3	Red		Red Circle Indication (AC,Line)
4	Green		Green Circle Indication (AC,Line)
5	Orange		Yellow Circle Indication (AC,Line)
6	Blue		Yellow Arrow Indication (AC,Line)
7	White	Black	Green Arrow Indication (AC,Line)

(b) Signal Cable - Pedestrian Signal Head

Conductor No.	Base Color	Tracer Color	Connection
1	Black		
2	White		AC, Neutral
3	Red		Don't Walk (AC,Line)
4	Green		Walk (AC,Line)

(c) Signal Cable - Pedestrian Push-Button

Conductor No.	Base Color	Tracer Color	Connection
1	Black		24 V DC
2	White		Cabinet Logic Ground

(d) Lead-in Cable (Single-Pair)

Conductor No.	Color	Connection
1	Black	Loop Detector - Loop Signal
2	Non-Black	Loop Detector - Loop Neutral

(e) Communication Cable or Lead-in Cable (Multipair)

Conductor No. (Each Pair)	Color	Connection
1	Black	Signal
2	Non-Black	Neutral/Logic Ground

(f) Service Cable

Conductor No.	Color	Connection
1	Black	AC, Line
2	White	AC, Neutral

The length of cable slack shall be provided according to the following schedule:

Location	Length of Slack Cable meters	(feet)
Gulfbox	0.5	1.5
Junction Box	0.5	1.5
Handhole	2.0	6.5
Double Handhole	4.0	13.0

Cable splices shall be made only at connections to detector loops or at the locations specified on the plans. When making a cable splice, the following procedures shall be used.

- Remove all outer cable coverings, leaving 100 mm (4 in.) of insulated wire exposed.
- Remove insulation for 25 mm (1 in.) and scrape copper conductors.
- Connect conductors by twisting and soldering together.

- (d) Wrap each conductor separately with rubber or vinyl electrical tape. The wrapping shall completely cover the twisted connection and the insulation 25 mm (1 in.) beyond all exposed copper wire on either end of the connection.
- (e) Scrape the cable sheath clean and place the cable in a rigid mold or a container. The mold or container shall be of a type acceptable to the Engineer.
- (f) Center all conductors in mold or containers.
- (g) Fill the mold or container with epoxy resin or polyurethane compound. The epoxy resin or polyurethane compound used shall be dielectric, waterproof, and approved by the Engineer.

All stranded conductors shall be terminated in the cabinet using crimp-on connectors.

Electric cables shall be pulled into conduit by training the cables at the entrance to the conduit to prevent twisting or overlapping. Detector lead-in cables shall be placed on top of signal cables. When 3 or more cables are pulled into a conduit, a fast-drying, water based lubricant recommended by the cable manufacturer shall be applied on the cables.

873.04 Method of Measurement. Electric cable will be measured for payment in meters (feet) in place. The length of measurement shall be the distance horizontally and vertically measured between the changes in direction, including cables in mast arms, mast arm poles, signal posts, and slack cables. The vertical cable length shall be measured according to the following schedule:

Location	Cable Length
Foundation (signal post, mast arm pole, controller cabinet)	1 m (3 ft)
Mast Arm Pole (mast arm mounted signal head)	6 m (20 ft)
Mast Arm Pole (bracket mounted signal head attached to mast arm pole)	4 m (13 ft)
Signal Post (bracket or post mounted signal head)	4 m (13 ft)
Pedestrian Push Button	2 m (6 ft)

873.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for ELECTRIC CABLE of the type, size, and number of conductors specified.

The lengths of slack cable allowed and the vertical cable allowed will be paid for at the contract unit price per meter (foot) for ELECTRIC CABLE IN CONDUIT.

The type specified will indicate the method of installation and whether the electric cable is Service, Signal, Lead-in or Communication.

POST AND FOUNDATION

SECTION 875. TRAFFIC SIGNAL POST

875.01 Description. This work shall consist of furnishing a metal traffic signal post of the length specified and installing it on a concrete foundation.

875.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Traffic Signal Post	1077.01
(b) Concrete	1020

CONSTRUCTION REQUIREMENTS

875.03 Installation. The traffic signal post shall be erected plumb, securely bolted to a concrete foundation, and grounded to a ground rod according to the details shown on the plans. No more than 20 mm (3/4 in.) of the post threads shall protrude above the base. The vertical clearance between the bottom of a bracket or post mounted signal head or pedestrian signal head and the crown of the pavement shall be between 2.5 m (8 ft) and 4.5 m (15 ft).

When the signal head is not mounted on the top of the post, a pipe cap shall be furnished and installed on the top of the post. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

Prior to the assembly, the Contractor shall apply two additional coats of galvanized paint on the threads of the post and the base. The Contractor shall use a fabric post tightner to screw the post to the base.

875.04 Basis of Payment. This work will be paid for at the contract unit price each for TRAFFIC SIGNAL POST of the type and length specified.

When a particular kind of material is specified for the post and base assembly, the work will be paid for at the contract unit price each for TRAFFIC SIGNAL POST, PAINTED STEEL; TRAFFIC SIGNAL POST, GALVANIZED STEEL, or TRAFFIC SIGNAL POST, ALUMINUM.

SECTION 876. PEDESTRIAN PUSH-BUTTON POST

876.01 Description. This work shall consist of furnishing a pedestrian push-button post and installing it on a concrete foundation.

876.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Pedestrian Push-Button Post.....	1077.02
(b) Traffic Signal Post	1077.01
(c) Concrete	1020

CONSTRUCTION REQUIREMENTS

876.03 Installation. The pedestrian push-button post shall be installed plumb on a concrete foundation according to the details shown on the plans. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

The foundation shall be made of Class SI Concrete.

876.04 Basis of Payment. This work will be paid for at the contract unit price each for PEDESTRIAN PUSH-BUTTON POST, TYPE I or PEDESTRIAN PUSH-BUTTON POST, TYPE II.

When a galvanized post is specified, the work will be paid for at the contract unit price each for PEDESTRIAN PUSH-BUTTON POST, TYPE I, GALVANIZED or PEDESTRIAN PUSH-BUTTON POST, TYPE II, GALVANIZED.

SECTION 877. MAST ARM ASSEMBLY AND POLE

877.01 Description. This work shall consist of furnishing a steel mast arm assembly and pole of the arm length specified and installing it on a concrete foundation.

877.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Mast Arm Assembly and Pole	1077.03

CONSTRUCTION REQUIREMENTS

877.03 Installation. The components of a mast arm assembly and pole shall be assembled and erected according to the details shown on the plans. The pole shall be erected vertically on a concrete foundation. The Contractor shall furnish and install the required nuts and washers for mounting and plumbing the pole on the anchor rods. After the entire assembly has been aligned and plumbed, a stainless steel mesh 6 mm (1/4 in.) maximum opening with a minimum wire diameter 1.5 mm (AWG No. 16) shall be stainless steel banded to the anchor rods with a minimum 50 mm (2 in.) lap to enclose the void between the mast arm base plate and the concrete foundation. The pole shall be grounded according to Article 807.01.

The Contractor shall take precautions to avoid scratching the galvanized coating on the mast arm pole and assembly during the transportation and erection. If it is

scratched, the Contractor shall touch up the scratches to the galvanized coating with a same color galvanized paint recommended by the pole manufacturer. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

A combination mast arm assembly and pole shall not be installed without the luminaire.

877.04 Basis of Payment. This work will be paid for at the contract unit price each for STEEL MAST ARM ASSEMBLY AND POLE or STEEL COMBINATION MAST ARM ASSEMBLY AND POLE of the signal arm length specified.

SECTION 878. TRAFFIC SIGNAL CONCRETE FOUNDATION

878.01 Description. This work shall consist of furnishing and installing a concrete foundation for the installation of a traffic signal post, controller base, or mast arm pole.

878.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Grounding Electrode	1087.01(b)
(b) Concrete	1020
(c) Reinforcement Bars	1006.10(b)

CONSTRUCTION REQUIREMENTS

878.03 General. Concrete foundations of the type specified shall be constructed as shown on the plans. The top of the foundation shall be finished level. Shimming of the appurtenance to be attached will not be permitted. A form extending a minimum of 225 mm (9 in.) below the top surface of the foundation is required. The form shall be set level, and means shall be provided for holding it rigidly in place while the concrete is being deposited.

Where a concrete foundation is contiguous to a sidewalk, preformed joint filler of 12 mm (1/2 in.) thickness shall be placed between the foundation and the sidewalk.

All conduit in the foundation shall be installed rigidly in place before concrete is deposited in the form. Bushings shall be provided at the ends of conduit. Anchor rods and ground rod shall be set in place before the concrete is deposited by means of a template constructed to space the anchor rods according to the pattern of the bolt holes in the base of the appurtenance to be attached.

- (a) Square or Rectangular Foundations. Whenever the excavation is irregular, a form shall be used to provide the proper dimension of the entire foundation below the ground surface.
- (b) Drilled Type Foundations. The hole for the foundation shall be made by drilling with an auger, of the same diameter as the foundation. If soil

conditions require the use of a liner to form the hole, the liner shall be withdrawn gradually as the concrete is deposited.

878.04 Method of Measurement. The foundation will be measured for payment in meters (feet) in place.

878.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) of depth of CONCRETE FOUNDATION of the type specified, which price shall be payment in full for all necessary excavating or drilling, backfilling, disposal of unsuitable material, form work, and furnishing all materials within the limits of the foundation, except the anchor bolts.

When the contract does not contain a unit price for rock excavation for structures and rock is encountered, it will be paid for according to Article 109.04.

SECTION 879. DRILL EXISTING FOUNDATION OR HANDHOLE

879.01 Description. This work shall consist of drilling a hole in an existing concrete foundation or handhole and for furnishing and installing a new conduit.

CONSTRUCTION REQUIREMENTS

879.02 General. The size of the hole shall be as close as possible to the size of the conduit. A conduit of the size required shall be installed in the drilled hole. A bushing shall be provided at the end of the conduit. The space between the conduit and the foundation shall be caulked with a waterproof grout.

879.03 Basis of Payment. This work will be paid for at the contract unit price each for DRILL EXISTING FOUNDATION or DRILL EXISTING HANDHOLE which price shall include all necessary excavation and backfilling outside of the foundation or handhole.

SIGNAL HEAD

SECTION 880. SIGNAL HEAD AND OPTICALLY PROGRAMMED SIGNAL HEAD

880.01 Description. This work shall consist of furnishing and installing a signal head or an optically programmed signal head.

880.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Signal Head and Optically Programmed Signal Head.....	1078.01

CONSTRUCTION REQUIREMENTS

880.03 Installation. The signal head or optically programmed signal head shall be installed on a post, bracket, span wire, or mast arm as shown on the plans. Other methods of attaching the signal head to a post, a mast arm pole, or a mast arm may be used upon approval by the Engineer. Signal heads consisting of only one face and up to three sections may be post mounted.

Each signal face shall be pointed in the direction of the approaching traffic it is to control and be aimed to have maximum effectiveness for an approaching driver located at a distance from the stop line equal to the normal distance traversed while stopping. The optic all programmed signal face shall be veiled according to the visibility requirements at the direction of the Engineer.

The size of each signal lens shall be 300 mm (12 in.).

During construction and until the installation is placed in operation, all signal faces shall be hooded. The hooding material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the hooding materials shall differentiate the signal as being hooded.

880.04 Basis of Payment. This work will be paid for at the contract unit price each for SIGNAL HEAD or OPTICALLY PROGRAMMED SIGNAL HEAD of the type specified and of the particular material type when specified.

If a signal head with both conventional and optically programmed signal faces is required, it will be paid for as a COMBINATION SIGNAL HEAD.

The type specified will indicate the number of signal faces, the number of signal sections in each signal face, and the method of mounting.

SECTION 881. PEDESTRIAN SIGNAL HEAD

881.01 Description. This work shall consist of furnishing and installing a pedestrian signal head.

881.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Signal Head and Optically Programmed Signal Head	1078.01
(b) Pedestrian Signal Head	1078.02

CONSTRUCTION REQUIREMENTS

881.03 Installation. The pedestrian signal head shall be installed on a post or bracket as shown on the plans. Other methods of attaching the pedestrian signal head to a post or a mast arm pole may be used upon approval by the Engineer.

Each pedestrian signal face shall be aimed to provide maximum visibility at the beginning of the controlled crossing.

The size of the pedestrian signal face shall be Class 2, 3, or 4 according to the ITE Standards. All pedestrian signal faces of one intersection shall be of the same Class and design.

During construction and until the installation is placed in operation, all pedestrian signal faces shall be hooded. The hooding material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the hooding material shall differentiate the pedestrian signal faces as being hooded.

881.04 Basis of Payment. This work will be paid for at the contract unit price each for PEDESTRIAN SIGNAL HEAD of the type and of the particular kind of material when specified.

The type specified will indicate the number of faces and the method of mounting.

SECTION 882. TRAFFIC SIGNAL BACKPLATE

882.01 Description. This work shall consist of furnishing a traffic signal backplate and attaching it to a traffic signal face.

882.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Traffic Signal Backplate	1078.03

CONSTRUCTION REQUIREMENTS

882.03 Installation. The traffic signal backplate shall be securely attached to a traffic signal face with noncorrosive bolts, locknuts, and washers. At least one bolt shall be used on each side of a signal section in contact with the backplate.

882.04 Basis of Payment. This work will be paid for at the contract unit price each for TRAFFIC SIGNAL BACKPLATE of the type and of the particular kind of material when specified.

SECTION 883. DIRECTIONAL LOUVER

883.01 Description. This work shall consist of furnishing and installing a directional louver for a 300 mm (12 in.) signal lens in the signal heads.

883.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Directional Louver	1078.04

CONSTRUCTION REQUIREMENTS

883.03 Installation. The directional louver shall provide an angle of cutoff on each side of the center axis of the light beam as follows:

Type A	0 degrees
Type B	7 to 10 degrees
Type C	11 to 14 degrees

The directional louver shall be installed inside the signal visor in front of the signal lens and secured in place with a minimum of two metal screws.

883.04 Basis of Payment. This work will be paid for at the contract unit price each for DIRECTIONAL LOUVER, of the type specified.

When used with a 200 mm (8 in.) lens, this work will be paid for at the contract unit price each for DIRECTIONAL LOUVER, of the type specified.

DETECTION**SECTION 885. INDUCTIVE LOOP DETECTOR**

885.01 Description. This work shall consist of furnishing and installing an inductive loop detector.

885.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Inductive Loop Detector	1079.01

CONSTRUCTION REQUIREMENTS

885.03 Installation. The inductive loop detector shall be installed inside a traffic signal controller cabinet. the detector shall be either card rack type or shelf-mounted type. The detector may be single-channel, two-channel, or four-channel.

885.04 Basis of Payment. This work will be paid for at the contract unit price each for INDUCTIVE LOOP DETECTOR or INDUCTIVE LOOP DETECTOR WITH SYSTEM OUTPUT, which price shall include the necessary connections and adjustments for proper operation.

If the detector unit has more than one complete detection channel, each complete detection channel will be considered as a detector for payment.

SECTION 886. DETECTOR LOOP

886.01 Description. This work shall consist of furnishing and installing a detector loop in the pavement.

886.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Detector Loop and Sealer	1079.02

The detector loop and sealer shall be according to the recommendations of the manufacturer of the related inductive loop detector as needed for proper operation.

CONSTRUCTION REQUIREMENTS

886.03 Testing. The detector loop shall be tested according to Article 802.08(a).

886.04 Installation. The detector loop location, shape, size, and the number of turns shall be as shown on the plans or as recommended by the manufacturer of the related inductive loop detector. Multiple loops connected to the same detector channel shall be connected in series or as directed by the Engineer. The detector loop shall be installed in the pavement according to the details shown on the plans and the following requirements:

- (a) Type I detector loop shall consist of furnishing a detector loop wire enclosed in a flexible tubing and installing it in a sawed slot in the pavement.

The sawed slot shall be clean, dry, and have a smooth bottom. Diagonal saw cuts or drilled holes shall be made at all corners to prevent sharp bends in the wire. The saw cuts at the corners shall be overlapped so they have full depth. The slot shall be cleaned by air pressure removing any debris and water, if any present. Each tube containing the loop wire shall be pushed into the saw cut with a wooden stick and not with any metal tool.

Retainers shall be added to the sawed slot to prevent the loop wires from floating during the pouring of the loop sealant. These retainers shall be 25 mm (1 in.) pieces of the tubing bent in half. The loop wires not embedded in the pavement shall be evenly twisted approximately 16 turns per meter (5 turns per foot).

- (b) Type II detector loop shall consist of furnishing a mineral-insulated metal-sheathed cable, installing it on a bituminous or portland cement concrete base course and covering it with a bituminous surface course. The surface course shall be between 50 and 125 mm (2 and 5 in.) thick. The cable shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The leads shall be bound together with tie wraps or fish tape rope, inserted through the hole, and positioned in place to make splices in the junction box or handhole.

The end of the cable shall be stripped, insulated and installed in a sleeve assembly according to the manufacturer's instructions to prevent moisture from entering the cable. The sleeved conductors shall be spliced together to form one continuous length. As each splice is made, it shall be metered to ensure a proper connection. The conductors must be soldered together and each conductor completely wrapped with two layers of rubber or vinyl electrical tape.

(c) Type III detector loop.

- (1) Rigid plastic conduit. This detector loop shall consist of furnishing a detector loop wire sealed with asphalt rubber or waterproof flexible sealant inside a rigid plastic conduit, installing it on a bituminous or portland cement concrete base course and covering it with a bituminous surface course. The surface course shall be between 50 and 125 mm (2 and 5 in.) thick. The conduit shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The plastic conduit shall be inserted through the hole toward the junction box or handhole.
- (2) Heavy duty reinforced rubber conduit. This detector loop shall consist of furnishing a detector wire sealed with asphalt rubber or waterproof flexible sealant inside a conduit made of heavy duty reinforced rubber hose. When the detector loop is installed on a bituminous or portland cement concrete base course, and covered by a bituminous surface course, the surface course shall be between 50 and 125 mm (2 and 5 in.) thick. When the detector loop is covered by portland cement concrete surface course, the surface course shall be between 50 and 400 mm (2 and 16 in.) thick. The conduit shall be secured to the base course by a method approved by the Engineer. The conduit shall be secured to reinforcing steel in the pavement, at each point the conduit crosses the reinforcing steel, in order to prevent shifting of the loop as the surface course is poured. When loops are secured to the top of reinforcing steel, care must be taken to prevent the steel from cutting into the conduit when the portland cement concrete surface course is poured over the top. In new roadways, the conduit may be placed directly on top of the gravel substrate.

886.05 Method of Measurement. This work shall be measured for payment in meters (feet) in place. Type I detector loop shall be measured along the sawed slot in the pavement containing the loop and lead-in, rather than the actual length of the wire. Type II and Type III detector loops shall be measured along the detector loop and lead-in embedded in the pavement, rather than the actual length of the wire.

886.06 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for DETECTOR LOOP of the type specified.

SECTION 887. EMERGENCY VEHICLE PRIORITY SYSTEM

887.01 Description. This work shall consist of furnishing a light transmitter, furnishing and installing a light detector, or a light detector amplifier, for an emergency vehicle priority system.

887.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Emergency Vehicle Priority System	1072

CONSTRUCTION REQUIREMENTS

887.03 Installation. The light transmitter shall be furnished to the user as directed by the Engineer.

The light detector shall be installed on or near a traffic signal head with necessary connections for proper operation, as indicated on the plans. The confirmation beacon shall be installed near the light detector or as indicated on the plans and shall face in the same direction as the corresponding light detector.

The light detector amplifier shall be installed inside a traffic signal controller cabinet or in the light detector housing.

887.04 Basis of Payment. This work will be paid for at the contract unit price each for LIGHT TRANSMITTER, LIGHT DETECTOR, or LIGHT DETECTOR AMPLIFIER.

Furnishing and installing a confirmation beacon shall be included in the cost of the light detector.

SECTION 888. PEDESTRIAN PUSH-BUTTON

888.01 Description. This work shall consist of furnishing and installing a pedestrian push-button and an appropriate traffic signal instruction sign.

888.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Pedestrian Push-Button	1074.02

CONSTRUCTION REQUIREMENTS

888.03 Installation. The pedestrian push-button shall be mounted approximately 1050 mm (42 in.) above the sidewalk level. The mounting saddle shall be completely in contact with the post or pole on which it is mounted. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly. The methods of mounting both the pedestrian push-button and the sign shall be approved by the Engineer.

The traffic signal instruction sign applicable to pedestrians shall be according to the National MUTCD, i.e., signs in series R 10-1 through R 10-4.

888.04 Basis of Payment. This work will be paid for at the contract unit price each for PEDESTRIAN PUSH-BUTTON.

MISCELLANEOUS

SECTION 890. TEMPORARY TRAFFIC SIGNAL

890.01 Description. This work shall consist of furnishing, installing, maintaining, and removing a temporary traffic signal installation as shown on the plans.

CONSTRUCTION REQUIREMENTS

890.02 Installation. The Contractor shall notify the Engineer at least 48 hours in advance when the temporary signal installation is ready to be activated. The Engineer will then inspect the installation. After approval by the Department, the maintenance of the temporary signal installation, including all energy charges, shall become the responsibility of the Contractor until removal is directed by the Engineer.

After the removal of the temporary installation, the equipment and materials furnished by the Contractor shall remain the property of the Contractor.

890.03 Maintenance. The temporary traffic signal maintenance shall be according to Article 802.07.

890.04 Basis of Payment. This work will be paid for at the contract unit price each for TEMPORARY TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

Following approval of each installation 60 percent of the bid price will be paid. The remaining 40 percent will be paid following removal of each installation.

SECTION 891. ILLUMINATED SIGN

891.01 Description. This work shall consist of furnishing and installing an illuminated sign with the lamp intensity control device and the step-down transformer for the fiber-optic sign.

891.02 Materials. Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Illuminated Sign	1084.05

891.03 Basis of Payment. This work will be paid for at the contract unit price each for ILLUMINATED SIGN, FLUORESCENT or ILLUMINATED SIGN, FIBER-OPTIC.

REMOVAL AND RELOCATION**SECTION 895. REMOVAL, RELOCATION, AND REBUILDING OF EXISTING SIGNAL AND APPURTENANCES**

895.01 Description. This work shall consist of the removal, removal and relocation, and or the rebuilding of existing signal items and appurtenances in the construction of signalized intersections.

CONSTRUCTION REQUIREMENTS

895.02 Relocation. All existing signal items shall be removed and relocated as shown on the plans. The installation shall be done according to the specifications for the specific item. Any damage done to the existing signal items or appurtenances shall be repaired or replaced by the Contractor at his/her own expense, as directed by the Engineer.

Relocation of the existing traffic signal controller and its associated equipment shall also consist of reusing the controller cabinet. Anchor rods, nuts, and washers shall be new for the installation of an existing traffic controller. The controller shall be installed according to Article 857.03.

Relocation of an existing signal head shall consist of removing an existing signal head, optically programmed signal head, or combination signal head and installing it according to Article 880.03.

Installation of the pedestrian signal head shall be according to Article 881.03.

Installation of an existing illuminated sign shall be according to Section 891.

Relocation of an existing signal post, controller cabinet, or mast arm assembly and pole shall include the removal and installation on a new concrete foundation with new anchor rods, nuts, and washers, according to Article 878.03.

When removing an existing pedestrian push-button, the related sign shall be removed and installed at the new location. The push-button will be installed according to Article 876.03.

This work shall consist of rebuilding the components of one or more existing signal heads into a required type signal head as noted on the plans, which may require removing old components and/or adding new components.

895.03 Rebuilding Signal Head. The existing signal components shall be removed and altered by adding or removing signal faces and/or mounting hardware. The additional signal faces and/or sections shall be of the same type and make as the existing signals. All lenses and reflectors shall be cleaned, and the reassembled signal head shall be cleaned and repainted. Rebuilding an existing signal head may require removing old components and/or adding new components. All components removed from the existing signal head and not reused shall be disposed of as directed by the Engineer. The Contractor may, without additional compensation,

furnish all new components, in lieu of rebuilding. Installation shall be according to Article 880.03.

895.04 Modifying Existing Controller. This work shall consist of modifying an existing controller to change the existing sequence of operation to the proposed sequence of operation. Both the existing and the proposed sequence of operation will be shown on the plans. Upon completion, the Contractor shall furnish the Engineer five copies of the cabinet wiring diagram.

895.05 Removal.

- (a) Existing Traffic Signal Equipment. The existing traffic signal equipment at an intersection shall be removed and disposed of as listed on the plans and as directed by the Engineer. The Contractor shall be responsible for repairing or replacing any items of equipment damaged during the process to the satisfaction of the Engineer.

All equipment shall be stored off the job site at an approved location, and electrical components shall be stored indoors.

- (b) Handhole. The frame and cover of an existing handhole shall be broken off the top section of the handhole wall to a minimum depth of 900 mm (3 ft) below the surrounding grade, or as specified, backfilled with approved material, and the surface reconstructed to match the adjoining area. The concrete debris shall be disposed of outside the right of way, and the frame and cover disposed of as directed by the Engineer. If the handhole is located in the sidewalk area, the entire sidewalk square or squares where the handhole is located shall be replaced with new sidewalk.

- (c) Concrete Foundation. The concrete foundation shall be removed to a level at least 900 mm (3 ft) below the adjacent grade, backfilled with approved material, and the surface reconstructed to match the adjoining area. The foundation shall be disposed of outside the right of way. If the concrete foundation is located in the sidewalk area, the entire sidewalk square or squares where the concrete foundation is located shall be replaced with new sidewalk.

- (d) Electric Cable from Conduit. An existing electric cable shall be removed, as directed by the Engineer, from a conduit.

895.06 Removal and Reinstallation. This work shall consist of removing an existing electric cable from a conduit and then reinstalling it in an existing or a new conduit. The conduit shall be cleaned and swabbed prior to reinstallation of cable.

895.07 Method of Measurement. Removal and removal and reinstallation of existing electric cable will be measured for payment in place in meters (feet). If two or more cables in a conduit are to be removed or removed and reinstalled, each cable will be measured for payment separately.

895.08 Basis of Payment. Removal and Relocation will be paid for at the contract unit price each for RELOCATE EXISTING SIGNAL HEAD, RELOCATE EXISTING PEDESTRIAN SIGNAL HEAD, RELOCATE EXISTING ILLUMINATED SIGN, and RELOCATE EXISTING PEDESTRIAN PUSH-BUTTON.

Removal and reinstallation of existing traffic signal items will be paid for at the contract unit price each for RELOCATE EXISTING TRAFFIC SIGNAL CONTROLLER, RELOCATE EXISTING TRAFFIC SIGNAL POST, or RELOCATE EXISTING MAST ARM ASSEMBLY AND POLE.

Concrete foundations, when specified, will be measured and paid for according to Section 878.

Rebuilding and existing signal head will be paid for at the contract unit price each for REBUILD EXISTING SIGNAL HEAD.

Modifying an existing controller will be paid for at the contract unit price each for MODIFY EXISTING CONTROLLER. Some of the parts and equipment required for the completion of this work may be listed on the plans as separate pay items. All other necessary parts, labor, and equipment required will be included in the cost of modifying the controller.

Removal of an existing electric cable will be paid for at the contract unit price per meter (foot) for REMOVE ELECTRIC CABLE FROM CONDUIT.

Removing and reinstalling the electric cable will be paid for at the contract unit price per meter (foot) for REMOVE AND REINSTALL ELECTRIC CABLE FROM CONDUIT.

Removal of existing traffic signal equipment will be paid for at the contract unit price each for REMOVE EXISTING TRAFFIC SIGNAL EQUIPMENT. Removal of existing handholes will be paid for at the contract unit price each for REMOVE EXISTING HANDHOLE. Removal of existing concrete foundations will be paid for at the contract unit price each for REMOVE EXISTING CONCRETE FOUNDATION.

